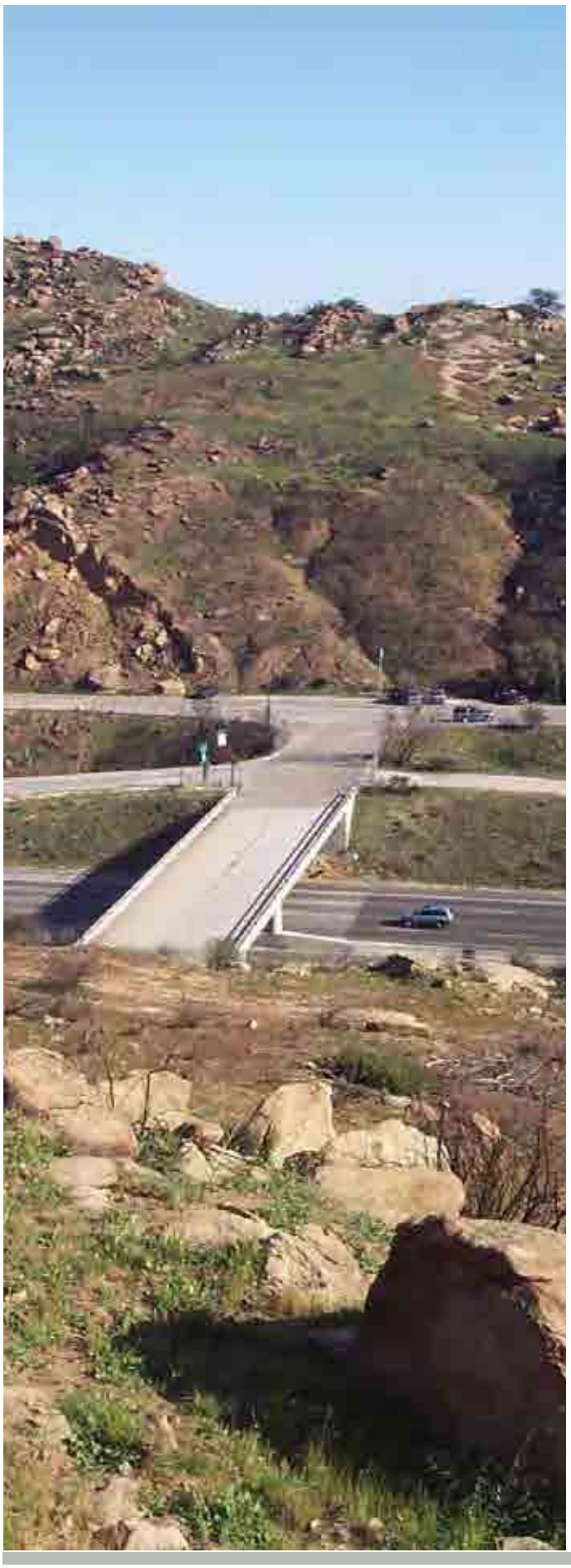

California Essential Habitat Connectivity Project:

A Strategy for Conserving a Connected California

February 2010

Prepared for:

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California Department of Fish and Game

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Federal Highways Administration

California Essential Habitat Connectivity Project
"A Strategy for Conserving a Connected California"

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Executive Summary

The California Department of Transportation (Caltrans) and California Department of Fish and Game (CDFG) commissioned the California Essential Habitat Connectivity Project because a functional network of connected wildlands is essential to the continued support of California's diverse natural communities in the face of human development and climate change. This Report is also intended to make transportation and land-use planning more efficient and less costly, while helping reduce dangerous wildlife-vehicle collisions.

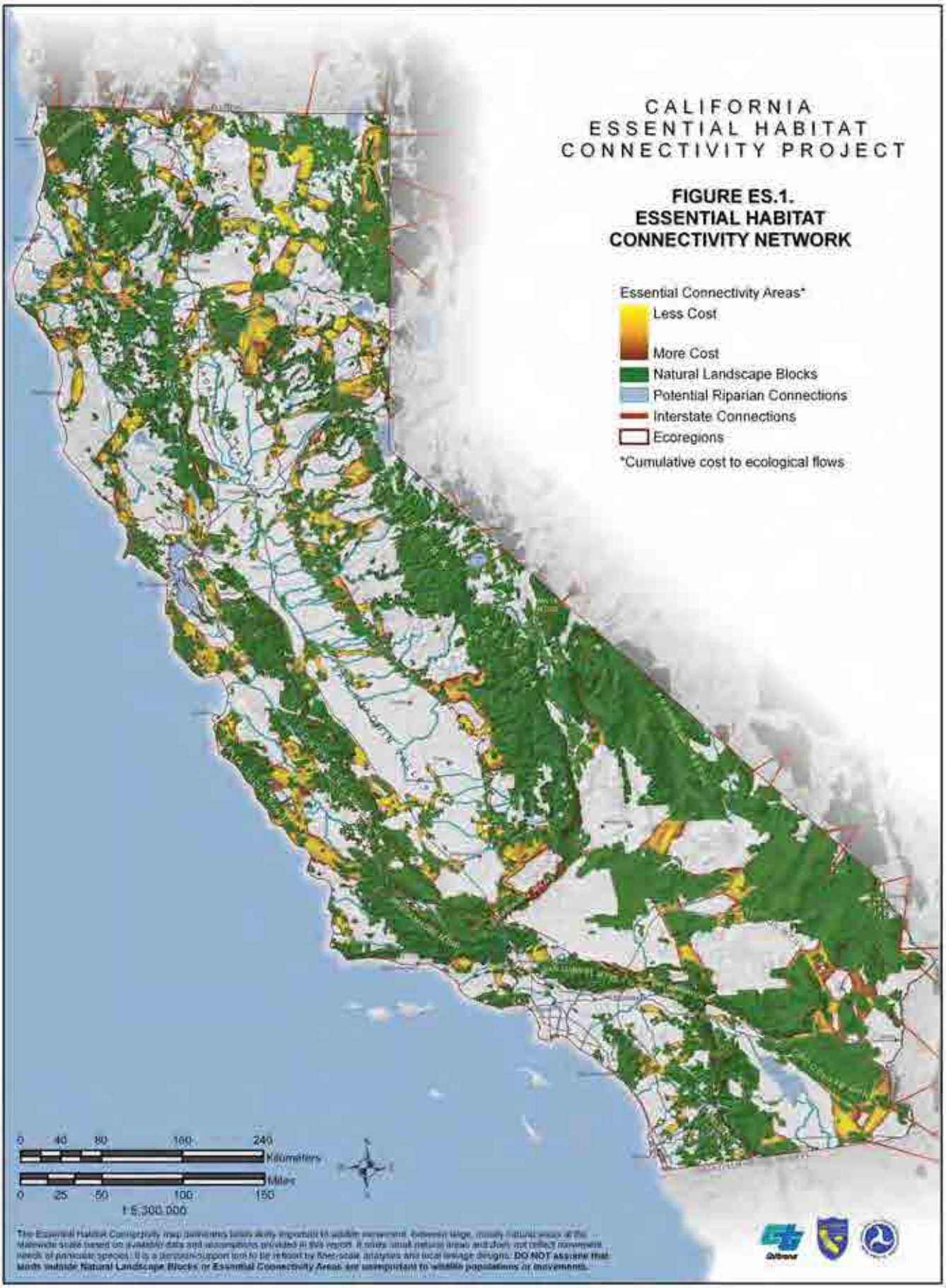
This Report was produced by a highly collaborative, transparent, and repeatable process that can be emulated by other states. The work was guided by input and review of a Multidisciplinary Team of agency representatives, a Technical Advisory Group, and a Steering Committee. The Multidisciplinary Team (~200 people from 62 agencies) provided broad representation across Federal, State, Tribal, regional, and local agencies that are involved in biodiversity conservation, land-use planning, or land management—and that could therefore both contribute to and benefit from efforts to improve habitat connectivity at various scales. The Technical Advisory Group (44 people from 23 agencies) was a subset of the Multidisciplinary Team. It provided technical expertise to help guide such decisions as selection of data sources, models, and mapping criteria. The Steering Committee (ten people from four partner agencies) guided key decisions about work flow, meeting agendas, and document contents. In addition to review by these agency representatives, the work plan and this final report were subject to peer review by five outside experts in conservation biology and conservation planning.

This Essential Habitat Connectivity Report includes three primary products: (1) a statewide Essential Habitat Connectivity Map, (2) data characterizing areas delineated on the map, and (3) guidance for mitigating the fragmenting effects of roads and for developing and implementing local and regional connectivity plans. These products will be made available for public use on two websites—BIOS, managed by the California Department of Fish and Game (http://bios.dfg.ca.gov), and Data Basin, managed by the Conservation Biology Institute (http://databasin.org). Both are interactive web-based systems that allow users to download, print, combine, comment on, or otherwise use the maps, data layers, and other information.

Essential Connectivity Map (Figure ES-1)

The Essential Connectivity Map depicts large, relatively natural habitat blocks that support native biodiversity (Natural Landscape Blocks) and areas essential for ecological connectivity between them (Essential Connectivity Areas). This coarse-scale map was based primarily on the concept of ecological integrity[1], rather than the needs of particular species.

[1] Natural Landscape Blocks were delineated based primarily on an Ecological Condition Index devised by Davis et al. (2003, 2006) using degree of land conversion, residential housing impacts, road impacts, and status of forest structure (for forested areas) as inputs. This index was modified by also considering degree of conservation protection and areas known to support high biological values, such as mapped Critical Habitat and hotspots of species endemism. Essential Connectivity Areas were delineated using least-cost corridor models


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE ES.1.
ESSENTIAL HABITAT
CONNECTIVITY NETWORK
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregions
*Cumulative cost to ecological flows
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analysis and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Essential Connectivity Areas are placeholder polygons that can inform land-planning efforts, but that should eventually be replaced by more detailed Linkage Designs, developed at finer resolution based on the needs of particular species and ecological processes. It is important to recognize that even areas outside of Natural Landscape Blocks and Essential Connectivity Areas support important ecological values that should not be "written off" as lacking conservation value. Furthermore, because the Essential Habitat Connectivity Map was created at the statewide scale, based on available statewide data layers, and ignored Natural Landscape Blocks smaller than 2,000 acres[2], it has errors of omission that should be addressed at regional and local scales, as discussed in Chapters 4-6.

The statewide essential connectivity network consists of 850 relatively intact and well-conserved Natural Landscape Blocks (ranging from 2,000 to about 3.7 million acres each) with over 1,000 potential connections among them. The 192 Essential Connectivity Areas represent principle connections between the Natural Landscape Blocks within which land conservation and management actions should be prioritized to maintain and enhance ecological connectivity. Each Essential Connectivity Area connects from 2 to 15 (on average 4.3) Natural Landscape Blocks across distances averaging roughly 10 to 20 km. In addition to these Essential Connectivity Areas, there are 522 instances where Natural Landscape Blocks were separated only by a road—in which case there was no need to delineate a connecting polygon, because sustaining and enhancing functional connectivity across roads is the primary or only conservation action needed (Chapter 6). In addition, the map illustrates that numerous riparian corridors contribute to ecological connectivity throughout the state; and sustaining and enhancing riparian and riverine corridors should remain a high conservation priority whether they are inside or outside of Essential Connectivity Areas and Natural Landscape Blocks.

Characterizing Natural Landscape Blocks and Essential Connectivity Areas

Data characterizing the Natural Landscape Blocks and Essential Connectivity Areas—including their size, physical characteristics, biological characteristics, ownerships, and the roads that cross them—are summarized in Chapter 3 and provided in detail in Appendices B and C. These data are also available in electronic databases so that users can select, sort, or weight the various attributes to help prioritize and plan conservation, mitigation, or other actions in or near the Essential Connectivity Areas and Natural Landscape Blocks.

Across the state, Natural Landscape Blocks average about 40% in private ownership and 44% in conservation reserves, with over 90% of their area in natural landcovers. Essential Connectivity Areas average about 15 km long, are about 61% in private ownership, have about 13% of their area in conservation reserves, and are over 80% natural landcovers. However, there is tremendous variability in attributes among California's eight diverse

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run on a data layer that represents the relative permeability of the landscape to wildlife movements, based on land cover naturalness, modified slightly to reflect conservation status.

[2] Only areas > 2,000 acres in size that met ecoregion-specific rules for Ecological Condition Index, degree of conservation protection, and support of known high-biological resource values were considered Natural Landscape Blocks. Only Natural Landscape Blocks > 10,000 acres were connected by Essential Connectivity Areas in most regions, and those > 2,000 acres were connected in more developed ecoregions (San Francisco Bay Area, Great Central Valley, South Coast, and Northern Sierra Nevada).

ecoregions and individual connectivity areas. Within each ecoregion, Essential Connectivity Areas tend to connect the most ecologically intact and well-conserved lands across generally less intact and protected land. However, optimal approaches to sustaining and enhancing functional connectivity will vary between ecoregions and individual Essential Connectivity Areas to reflect different contexts. For example, in the relatively undeveloped forest and desert ecoregions—such as the Sierra Nevada and Mojave Desert—many Essential Connectivity Areas connect highly intact wilderness and park lands across private or federally managed multiple-use lands, which support mostly natural landcovers and are relatively permeable to wildlife movements. In these "low-contrast" situations, managing to sustain wildlife movements between existing protected areas may be the primary conservation approach. In other, more human-altered ecoregions—such as the San Francisco Bay Area, Great Central Valley, and South Coast Ecoregion—Essential Connectivity Areas tend to connect existing reserves across lands with more roads, agriculture, and urbanization, which can constrain wildlife movements. In such "high-contrast" situations, there may be greater focus on restoration and enhancement actions to improve ecological connectivity.

The California Essential Habitat Connectivity network overlaps considerably with other conservation maps, and it should be seen as complementary to rather than replacing existing conservation maps and plans. For example, the network includes 76% of the protected lands in California, including 99.6% of National Parks, 91% of conservation lands administered by non-governmental organizations, 80% of California Department of Parks and Recreation lands, and 80% of various County conservation lands. The network also overlaps with 41% of the area covered by Habitat Conservation Plans and Natural Community Conservation Plans, and 80% of habitat considered essential to recovery of federally Threatened or Endangered species. Essential Connectivity Areas also support high biodiversity, with an average of 26 special status plant and animal taxa per Essential Connectivity Area. On average, 12% of the land area in Essential Connectivity Areas is Critical Habitat for species listed under the Endangered Species Act.

Although the Essential Connectivity Areas were mapped based on coarse ecological condition indicators, rather than the needs of particular species, Essential Connectivity Areas are expected to serve the majority of species in each region. For example, Essential Connectivity Areas in California's South Coast Ecoregion included on average 81% of the area in each of 11 detailed Linkage Designs prepared by the South Coast Missing Linkages project based on the needs of 14 to 34 focal species each. Nevertheless, how well the Essential Connectivity Network actually accommodates wildlife movements is uncertain and will vary tremendously among species and locations. Consequently, future work should focus on assessing functionality of the network for diverse wildlife species and refining the Essential Habitat Connectivity Map and the following recommendations based on the results.

Framework for Regional Analysis

Given the coarse nature of the Essential Habitat Connectivity Map and the difficulties inherent to prioritizing conservation across such a diverse landscape, this Report provides guidance for mapping connectivity networks at regional and local scales. Regional analyses (Chapter 4) are useful to (1) help planners comprehensively consider regional needs for

connectivity, including for natural areas smaller than those mapped in this statewide project; (2) prioritize Essential Connectivity Areas for more detailed planning; and (3) take advantage of spatial datasets not used in this Report because they did not cover the entire state. A regional analysis produces a map of all Natural Landscape Blocks (including small blocks), detailed and implementable conservation plans for the most important connectivity areas, and placeholder polygons for the remaining connectivity areas.

A good existing example of a regional analysis is South Coast Missing Linkages and the accompanying 11 individual Linkage Designs for the South Coast Ecoregion (available at www.scwildlands.org). The Linkage Designs were developed based on the habitat and movement needs of multiple focal species, and 10 of the 11 designs are being actively implemented.

In developing a regional connectivity analysis, it is important to involve end-users early in the design process to collectively agree on what types of areas they want to connect, which areas need connectivity, and which areas merit the highest priority for detailed Linkage Design. The entire process should be transparent and repeatable to build trust and allow updating as new or better data become available.

We recommend that regional connectivity analyses identify Natural Landscape Blocks by considering ecological integrity, protection status, biodiversity, and highways, and map Essential Connectivity Areas by least-cost modeling for a broad suite of focal species. In Chapter 4 we describe the advantages and disadvantages of alternative approaches, so that planners can choose the most appropriate methods for their region. If time and budget allow, we recommend conducting detailed Linkage Designs for all potential linkages in a region. More commonly, limited resources will compel planners to develop a few priority Linkage Designs at a time. Nonetheless every regional plan should replace the most crucial placeholder polygons with detailed Linkage Designs using methods described in Chapter 5.

Framework for Local-scale Analyses

The goal of local-scale analyses is to replace the relatively coarse Essential Connectivity Areas with detailed Linkage Designs—that is, maps delineating the specific lands needed to maintain or restore functional connections between two Natural Landscape Blocks and detailed descriptions of the necessary conservation and management actions. Chapter 5 provides a "cookbook" of step-wise procedures for each major step listed below. Except for the new procedures related to climate change, each set of instructions has a well-established history of use for local-scale analysis in California and elsewhere. Each step should involve collaboration among stakeholders, end-users, implementers, and scientific experts.

1. *Delineate Natural Landscape Blocks:* Connectivity is meaningful only with reference to the areas to be connected—whether they are existing protected areas, suitable habitat for select focal species, or other alternatives.

2. *Select focal species:* Choose focal species to represent a diversity of habitat requirements and movement needs. Focal species should include *area-sensitive species* (those with large area requirements, which are often the first to disappear when connectivity is lost),

barrier-sensitive species (those least likely to traverse roads, urban areas, canals, agricultural fields, or other features), and *less mobile species* (habitat specialists and those with limited movements).

3. *Map corridors for focal species:* Conduct least-cost corridor analyses for each focal species to identify one or more swaths of habitat that support movement and gene flow. Consult experts on each focal species to parameterize the model and review the results.
4. *Map corridors for climate change:* Add additional swaths of habitat to increase the utility of the linkage under an uncertain future climate. We offer an approach that identifies corridors based on *land facets*—or areas of relatively uniform physical conditions that represent the arenas of biological activity, rather than the temporary occupants of those arenas.
5. *Evaluate and refine the preliminary Linkage Design.* Even the most permeable landscape identified in the previous two steps may not be very permeable for some species. Therefore, assess the spatial distribution of habitat patches for each species and add habitat as needed to the Linkage Design to ensure each species is accommodated. Where possible, impose a minimum width of 2 km to allow occupancy by medium-sized animals and support networks of linked populations for less-mobile species that require multiple generations to move their genes between Natural Landscape Blocks.
6. *Assess the Linkage Design in the field:* Conduct fieldwork to ground-truth existing habitat conditions, document barriers and passageways, identify restoration opportunities, and consider management options.
7. *Develop a Linkage Design Action Plan:* Compile results of analyses and fieldwork into a comprehensive report detailing what is required to conserve and improve linkage function, including priority lands for conservation and specific management.

Each Linkage Design should be based on existing baseline conditions or (for highly altered areas such as the Central Valley) on context and restorability of habitats, rather than on potential future build-out scenarios. Basing the analysis on future development scenarios may obscure what could be optimal alternatives. Although compromises will occur during implementation, the biological optimum provides a useful reference condition, so that decision-makers can evaluate trade-offs and make good compromises.

Guidelines for Addressing Road Impacts

The ecological footprint of a road network extends far beyond its physical footprint due to road mortality, habitat fragmentation, and numerous indirect impacts. The Essential Habitat Connectivity analysis identified 552 pairs of Natural Landscape Blocks separated only by a road, and numerous roads cross Essential Connectivity Areas. Chapter 6 therefore provides guidelines for assessing where mitigating road impacts to wildlife movement and ecological connectivity will be most effective, along with guidelines for how best to enhance functional connectivity while reducing the hazards of vehicle-wildlife collisions. In locations where a road crosses a Natural Landscape Block in protected status, the strongest enhancement and mitigation measures should be used. Protected status represents a significant public

investment and commitment to ecological integrity, and roads should not compromise that investment.

Wildlife crossing structures—such as wildlife overpasses, underpasses, bridges, and culverts—can facilitate wildlife movement across roads, especially when integrated with appropriate roadside fencing. Because species vary tremendously in their reactions to roads, fences, and different types of crossing structures, multiple types of crossing structures should be constructed and maintained to provide connectivity for all species. The structures should be spaced close enough to allow free movement by species with different spatial requirements, and fencing should keep animals off the road and direct them towards crossing structures.

Strategies for Integrating and Institutionalizing the California Essential Habitat Connectivity Project

Maintaining and enhancing functional ecological connectivity across California's landscape in the face of human development and climate change is no easy task, and no single agency or small group of agencies can tackle it alone: The 200 members of the Multidisciplinary Team for this Project volunteered to serve as ambassadors for connectivity within and outside their agencies. As described in Chapter 7, each agency has a unique role to play in conserving ecological connectivity while also pursuing its own mission—whether it involves improving transportation, delivering water and power, providing recreational opportunities, or conserving biological diversity. Connectivity conservation fits all missions to some degree.

The Essential Habitat Connectivity Project was designed to be adopted and used to support planning at multiple scales. At the broadest scale, the products of this Project can serve new or emerging collaborations larger than the state of California, such as the 14-state Western Governors' Wildlife Council. At the statewide scale, the Project was intended to support conservation plans like California's Wildlife Action Plan and the California Climate Adaptation Strategy, and to integrate with infrastructure plans such as California Transportation Plan 2035. At regional and local scales, the products can be used to inform a wide array of planning efforts, such as Natural Community Conservation Plans and Habitat Conservation Plans, transportation Blueprint Plans, city and county General Plans, and land acquisition, management or restoration plans by conservancies, land trusts, and other non-governmental organizations. Private landowners may want to use this information to understand how they can be a part of a regional conservation goal or engage in the discussion. Legislation both supports and assures the conservation of connectivity in California.

Chapter 1. Introduction

1.1. Project Goals

The California Department of Transportation (Caltrans) and California Department of Fish and Game (CDFG) commissioned the California Essential Habitat Connectivity Project because a functional network of connected wildlands is essential to the continued support of California's diverse natural communities in the face of human development and climate change. This Essential Habitat Connectivity Report includes a statewide map of Essential Connectivity Areas and an assessment of these areas and the lands they connect. It also describes strategies for maintaining and enhancing functional ecological connectivity through local and regional land-use and management plans. These tools and strategies are provided to assist all agencies and organizations involved in land-use planning, transportation planning, land management, and conservation in California with maintaining a connected California, while simultaneously making land-use and infrastructure planning projects more cost efficient.

Contents of this Report are specifically intended to help Caltrans comply with Section 6001 of SAFETEA-LU[3] by avoiding, minimizing, and mitigating impacts to habitat connectivity during the transportation planning process. The information is also intended to help the California Department of Fish and Game update the State Wildlife Action Plan (Bunn et al. 2007) and comply with AB2785[4], which requires the Department of Fish and Game to map essential wildlife corridors and habitat linkages. The California Department of Fish and Game and the United States Fish and Wildlife Service (USFWS) also intend to use the plan to help during development and assessment of Natural Communities Conservation Plans (NCCPs), Habitat Conservation Plans (HCPs), and Habitat Management Plans (HMPs). Finally, the information in this Report is intended to help other land-planning and land-management agencies or non-governmental organizations to improve how natural open space, wildlife movement, and habitat connectivity are addressed in land-use, conservation, and transportation plans—including, for example, through local or regional General Planning and Transportation Planning processes, or via the operations of state, regional, or local conservancies and land trusts.

This document presents the methods used to prepare and assess the statewide Essential Connectivity Map, the maps and other information resulting from these analyses, and approaches and decision support tools for future work by implementing agencies. It includes three primary products:

1. The statewide Essential Connectivity Map, which broadly depicts large, relatively natural habitat blocks that support native biodiversity (Natural Landscape Blocks) and areas essential for ecological connectivity between them (Essential Connectivity Areas). The resulting network of Natural Landscape Blocks and Essential Connectivity Areas is considered important for maintaining native species, natural communities, and ecological

[3] Safe Accountable Flexible Efficient Transportation Equity Act of 2005
[4] California Assembly Bill 2785 (Ruskin)

processes throughout California. The map is very broad in scale, is not based on the needs of any particular species, and necessarily focuses on a finite number of approximate areas likely important for maintaining ecological connectivity. The map therefore excludes numerous areas that may be important to wildlife movement and ecological connectivity at more local scales. As outlined later in this Report, finer-scale analyses should be performed to identify and delineate these more local connectivity areas, as well as to refine the broad-brush Essential Connectivity Areas and Natural Landscape Blocks identified by this project using additional analytical tools, such as focal-species analyses.

2. Matrices summarizing characteristics of the Essential Connectivity Areas and the Natural Landscape Blocks they connect. These characteristics include data on the size, physical condition, and biological resources supported by these areas, as well as such characteristics as roads, topography, and existing degree of conservation that may influence land planning and management. The matrices are intended as decision-support tools for land-planning, land-management, and conservation agencies and organizations. Users of the matrices can select, sort by, or differentially weight the various attributes to help them prioritize and plan conservation, mitigation, or other actions in or near Essential Connectivity Areas and Natural Landscape Blocks.

3. Strategies for implementing habitat connectivity plans throughout the state, including guidance for developing finer-scale analyses and implementable connectivity plans at regional and local scales, standards and guidelines for addressing impacts of roads to ecological connectivity, and strategies for how various agencies and non-governmental organizations can integrate and institutionalize connectivity conservation in their planning processes and actions (Chapters 4 – 8). Given the broad-scale nature of the Essential Connectivity Map, completing finer-scale analyses, including refined delineation of the Essential Connectivity Areas and Natural Landscape Blocks, is considered a high priority for future analyses.

1.2. Project Approach

The approach used in this interagency project was highly collaborative, transparent, and repeatable. The work of the consulting team was guided by input and review of a Steering Committee, Multidisciplinary Team, and Technical Advisory Group via three in-person meetings and multiple web-based meetings, e-mail exchanges, and conference calls.

The Steering Committee was composed of staff members from California Department of Transportation, California Department of Fish and Game, U.S. Fish and Wildlife Service,

California Department of Parks and Recreation (DPR), and California Department of Water Resources (DWR). The Steering Committee worked closely with the Consultant Team on work flow, decision points, meeting structure and content, document editing, and overall project concerns. The team held regular web-based meetings with the Steering Committee to obtain input and review of interim products.

The Multidisciplinary Team was comprised of Federal, State, Tribal, regional, and local agencies that could potentially have interest in the project, including transportation planning agencies, regional planning agencies, regulatory agencies, and natural resources agencies. An initial project meeting was held on October 7, 2008, with invitations sent to over 250 members of the Multidisciplinary Team. At this meeting, an overview of the project goals was presented, with some background on connectivity planning. Members of the Multidisciplinary Team then broke out into groups and provided input to the Consultant Team regarding their goals and needs for the proposed project. Also at this meeting, Multidisciplinary Team members identified potential Technical Advisory Group members.

The Technical Advisory Group represents a subset of the Multidisciplinary Team with specific technical skills in geographic information systems (GIS), biology, land management, and other relevant expertise. Technical Advisory Group members were identified and selected to work more closely with the Steering Committee and Consultant Team. Key decisions on all technical matters, such as data sources and models to use to delineate Natural Landscape Blocks and Essential Connectivity Areas, were guided by the Technical Advisory Group. A second project meeting was held on January 29, 2009, with members of the Technical Advisory Group. At this meeting, the Technical Advisory Group provided input on the Draft Work Plan, the proposed modeling approach and criteria for defining Natural Landscape Blocks and Essential Connectivity Areas, and characteristics for describing the Essential Connectivity Areas.

After the second project meeting, the Consultant Team produced a Work Plan to guide the remainder of the project. Most of the methods described in this Report and used to develop the Essential Connectivity Map were originally detailed in multiple drafts of the Work Plan, which were reviewed by the Technical Advisory Group as well as several outside peer reviewers[5]. The Work Plan (attached as Appendix A) also served as a vehicle for keeping members of the Technical Advisory Group and Multidisciplinary Team apprised of revisions to methods and how their technical input was being addressed. Members of the Technical Advisory Group reviewed draft Natural

[5] Kevin Crooks, Colorado State University; Reed Noss, University of Central Florida; and John Wiens, PRBO Conservation Science.

Landscape Block and Essential Connectivity Area maps via web-based meetings. The Consultant Team also used Data Basin[6] and Google Docs as methods for sharing, receiving input, and refining maps, models, and other work products throughout the project.

A third project team meeting was held on October 15, 2009, to solicit input from the Technical Advisory Group on draft products, including maps of the Natural Landscape Blocks and Essential Connectivity Areas, comparisons with other conservation maps, criteria used to characterize the Essential Connectivity Areas and Natural Landscape Blocks, and the desired contents of this Report. The final project meeting, scheduled for February 10, 2010, was designed to release the final results and to review the recommendations and other contents of this Report with the Multidisciplinary Team.

1.3. Report Goals and Organization

This Report summarizes the methods and results of the California Essential Habitat Connectivity Project and provides a framework for local and regional analyses, as well as strategies for implementation. Chapter 2 details the Methods used in constructing the products for this project, including steps for delineating Natural Landscape Blocks and Essential Connectivity Areas. Chapter 3 showcases the results from this Project, including statewide and ecoregional Essential Connectivity maps, comparisons to other conservation maps, and characteristics of the Natural Landscape Blocks and Essential Connectivity Areas. Frameworks for moving forward with future, finer-resolution actions, including regional analyses, local-scale analyses and approaches to improving connectivity across roads are detailed in Chapters 4 through 6, respectively. Strategies for integrating and institutionalizing the results of this analysis are presented in Chapter 7. Chapter 8 presents a framework for data distribution and updating. Details concerning background technical information, data, detailed characteristics of Natural Landscape Blocks and Essential Connectivity Areas, and other supporting information are presented in the Appendices.

The work represented by this project is broad scale by nature. In order to accommodate the diversity and size of the State of California, detailed analyses were not possible, and thus this report and the Essential Habitat Connectivity Map represent only a first step toward maintaining and protecting essential habitat connectivity throughout the State. Much more work is needed to meet the project's ultimate goals.

[6] Data Basin (http://databasin.org/about_data_basin) is an innovative web tool that connects users with conservation datasets, tools, and expertise. Individuals and organizations can explore and download a vast library of conservation datasets, upload their own data, comment on or add to other's data, and produce customized maps and charts that can be easily shared.

Chapter 2. Methods

Constructing and assessing the statewide Essential Habitat Connectivity Map required five principle analytical steps:

1. Delineating the lands to connect (Natural Landscape Blocks).
2. Identifying which pairs of Natural Landscape Blocks to connect (by drawing "sticks" connecting neighboring blocks).
3. Delineating Essential Connectivity Areas (polygons) connecting the Natural Landscape Blocks using least-cost corridor models.
4. Characterizing the biological and physical attributes of the resulting network of Natural Landscape Blocks and Essential Connectivity Areas.
5. Comparing the Essential Habitat Connectivity Map to other conservation priority maps.

Decisions concerning the data and methods used at each step were guided by input and review from the Steering Committee and Technical Advisory Group, in an iterative fashion. The Consultant Team produced numerous draft maps and pilot tests using various data sources and modeling approaches, based on suggestions from the Steering Committee and Technical Advisory Group, which then reviewed the results and suggested revisions. The team strove to make the methods as transparent and repeatable as possible, generally guided by formal decision rules derived for each step; however fully automated and quantitative methods were not possible at every step, and implementation of decision rules sometimes required professional judgment. The methods, data sources, and rule sets used at each analytical step are detailed below.

2.1. Delineating Natural Landscape Blocks

The first step in any connectivity analysis is deciding what needs to be connected—whether these are existing reserves, suitable or occupied habitat for particular species, or large areas of relatively natural landcover (Beier et al. 2008). Intense discussions with the Multidisciplinary Team and Technical Advisory Group suggested that no single approach would satisfy all partners in all parts of the state, due to differing agency goals and mandates, as well as California's extreme biogeographic and geopolitical variability. In some regions and for some agencies, existing protected areas seemed the logical units to connect, whereas in others, large natural areas, whether conserved or not, seemed better. Nearly all parties favored focal-species, habitat-based approaches, but recognized that these would not be possible given schedule, data, and budgetary constraints—and again, the extreme biogeographic variability of the State (i.e., no species or set of species would provide an adequate and unbiased representation of areas needing connectivity). Ultimately, there was consensus that the Project should use an objective, state-wide index of ecological integrity or "naturalness" as the primary basis for defining Natural Landscape Blocks, supplemented or modified with some consideration of existing protected areas (especially in large, relatively unaltered regions like the deserts) as well as some consideration of areas known to support high-value biological resources, such as concentrations of endemic species or habitat considered essential to supporting Threatened or Endangered species.

2.1.1. Ecological Condition Index

After investigating various approaches for defining Natural Landscape Blocks based on indices of ecological integrity, it was decided that the best approach was to modify an existing published model of Ecological Condition Index (ECI) developed by Davis et al. (2003, 2006) for the California Legacy Project (http://legacy.ca.gov/). The Ecological Condition Index characterizes site resource quality statewide, at 100-m resolution, using the following components (see Davis et al. 2003 and 2006 for equations and further details):

- *Land Conversion.* This component rates each 100-m pixel based on whether or not it has been converted from relatively natural landcover by human land uses. A score of zero was applied to converted areas (urban, cropland, orchard, vineyard, improved pastures, and exotic tree plantations) and all other areas were scored 1.0 (data source: California Department of Forestry and Fire Protection [FRAP] 2003).
- *Residential Housing Impact.* The score of suburban and rural residential areas declined linearly with increasing housing density (FRAP 2003) to a score of zero at $\geq$ 1 house/2 ha (5 ac), at which point the cell was classified as urban.
- *Road Effects.* The score for road effects varied as a function of road class, cell distance from the road, and predicted traffic volume (data sources: Caltrans 2001, TIGER 2000 in U.S. Census Bureau 2002). Value increased according to a quadratic equation from 0 at the road midline to 1.0 at distances > 500 m from major roads or > 300 m from minor roads (local streets and unpaved rural roads).
- *Forest Structure.* The score for forest structure applied only within areas mapped as forest types (FRAP 2003) where trees can attain large, commercially harvestable size—such as Sierran mixed conifer or eastside pine—and not to such woodland types as pinyon-juniper woodland or oak woodland. The score is intended to represent the degree of modification in forest canopy structure by logging, silvicultural practices, or fire. Thus, the structure score declines from dense, late-seral, large-tree conditions, to more open, early seral, smaller-tree conditions. Scores were 0.33 for early seral forests (tree crowns less than 12-ft diameter for conifers and 30 ft for hardwoods) and 1.0 for mid-to-late seral forests (tree crown cover > 40% and tree crowns > 24-ft diameter for conifers and 45 ft for hardwoods). Intermediate forest structures were assigned a value of 0.66.

The four scores were combined using Boolean logic, such that an area in good condition for supporting native terrestrial biodiversity must be not converted AND must have low impact from residential development AND must not be affected by roads AND must have good forest structure in the event it is forested (Davis et al. 2003). Figure 2.1[7] is the Davis et al. (2003) Ecological Condition Index map, rescaled from 0 to 100.

[7].Note that small slivers near the corners of the state and it's western most point south of Eureka were not scored by Davis et al. (2003) (Figure 2.1), apparently an artifact of using a rectangular analysis envelope. Also, because Davis et al. (2003) extrapolated housing density over census blocks that can extend into areas with little or no housing from higher-density areas, some wild areas near cities scored lower than might be expected in ecological condition. Although these issues may lead to errors of omission in delineating Natural Landscape Blocks, they are at least partly compensated for by further modifications and rules described below.

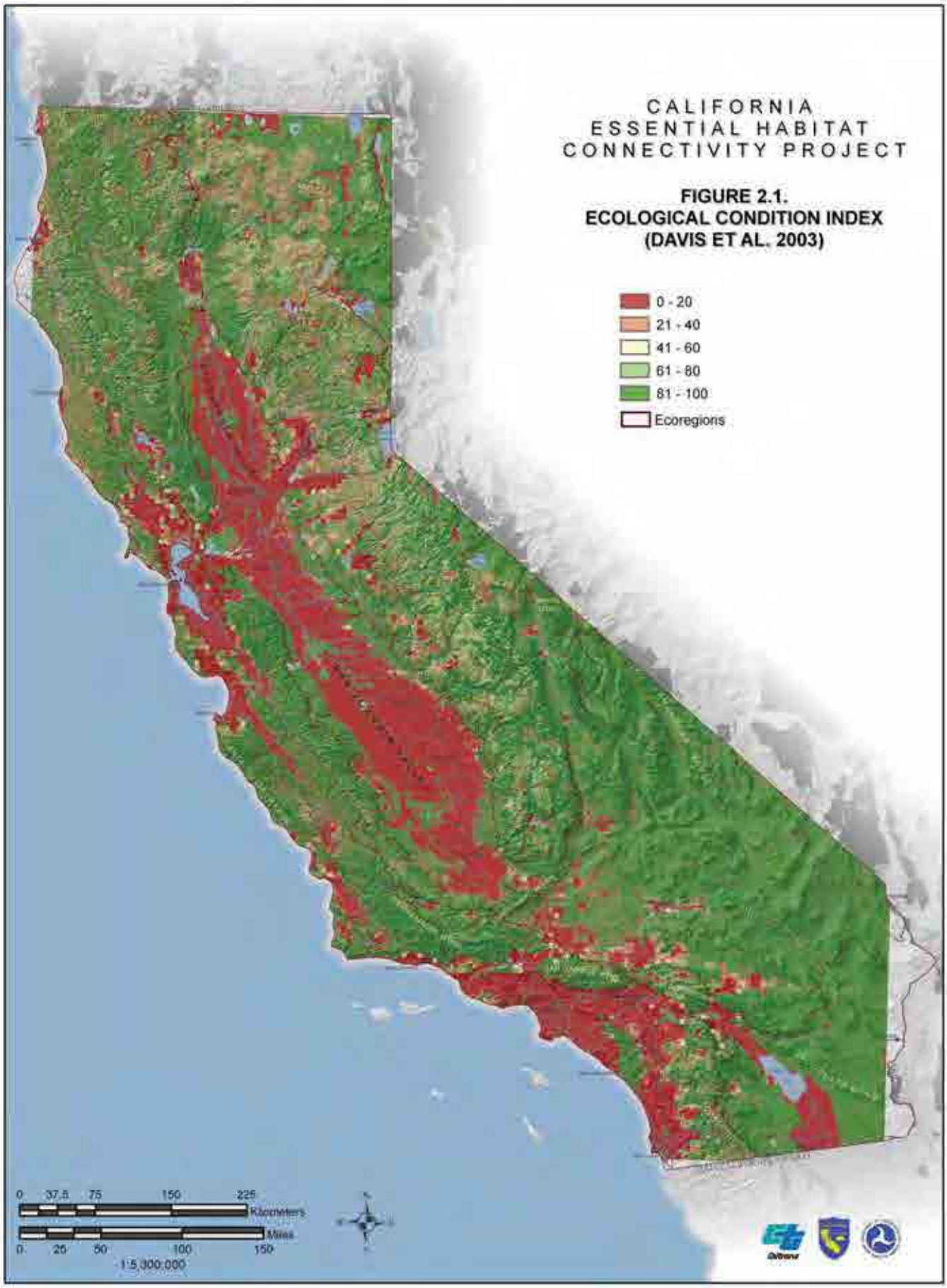
CALIFORNIA
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FIGURE 2.1.
ECOLOGICAL CONDITION INDEX
(DAVIS ET AL. 2003)
0 - 20
21 - 40
41 - 60
61 - 80
81 - 100
Ecoregions
0 37.5 75 150 225
Kilometers
Miles
0 25 50 100 150
1:5,300,000

2.1.2. Modifications to Ecological Condition Map

The Davis et al. (2003) Ecological Condition Index output was next modified for purposes of defining Natural Landscape Blocks by considering conservation protection status (GAP status) and areas known to have High Biological Value (HBV), as follows.

- *GAP Conservation Status*[8]. Lands conserved for wilderness or wildlife habitat values were considered likely to maintain high ecological integrity relative to, for example, multiple-use or unprotected lands. Moreover, these lands represent existing investments in conservation that need to be connected to preserve their continued functionality in supporting ecological values. Therefore, all lands having GAP status 1 or 2 (excluding Wild and Scenic Rivers) were delineated as preliminary Natural Landscape Blocks, regardless of Ecological Condition Index (Source: California Protected Area Database 2009, Conservation Biology Institute Protected Areas Database 2009, and SC Wildlands Protected Lands 2008).
- *High Biological Value.* Areas known to support important biological values, such as rare communities, endemic species, or essential habitat for Threatened or Endangered species, received heightened consideration for inclusion in Natural Landscape Blocks. Numerous data layers indicative of such High Biological Value areas were nominated by the Technical Advisory Group and reviewed for potential consideration in defining Natural Landscape Blocks. Only data layers resulting from systematic statewide assessments of resources and that would be useful for assessing terrestrial (not aquatic) connectivity qualified for inclusion, to avoid biasing against poorly studied regions[9]. Ultimately, an area was considered to have High Biological Value if any one or more of the following conditions were met:
    - Mapped as essential habitat or legally designated Critical Habitat for Threatened or Endangered species (Source: USFWS 2008). Essential habitat includes areas that support habitat features essential to survival and recovery of a species, as determined by U.S. Fish and Wildlife Service prior to consideration of economic impacts and land ownership issues that are also considered in designating Critical Habitat. Unlike Critical Habitat, essential habitat has no legal or regulatory implications, but is based purely on biological and physical considerations.
    - Wetlands or vernal pools (Sources: CDFG 1997, Holland et al. 1998, North Fork Associates 2000, Holland and USFWS 2003).

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[8] GAP protection status (Crist 2000). Status 1: permanent protection from conversion of natural landcover and a mandated management plan to maintain a natural state and disturbance events, e.g., designated wilderness, national parks. Status 2: permanent protection from conversion of natural landcover and a mandated management plan to maintain a primarily natural state, but may receive uses that degrade the quality of existing natural communities, including suppression of natural disturbance. Status 3: permanent protection from conversion of natural landcover for most of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining); protection to federally listed species throughout the area. Status 4: no public or private mandates or easements prevent conversion of natural habitat types to anthropogenic habitat types.

[9] Some biological values that were offered but could not be utilized due to lack of appropriate data layers included such factors as successional stage of the vegetation, susceptibility to disturbance, and presence of invasive species.

- Hotspots for amphibians, reptiles, mammals, or plants as mapped by California Department of Fish and Game using a rarity-weighted richness index on California Natural Diversity Database records. This index can be used as one measure of endemism or irreplaceability (CDFG 2003a).
- BLM Areas of Critical Environmental Concern (ACEC) that were designated based on biological values, rather than archaeological or other values (Source: U.S. BLM, 2000).

2.1.3. Block Designation Rules

The maps of Ecological Condition Index (Figure 2.1), Gap Conservation Status (Figure 2.2), and High Biological Value (Figure 2.3) were used to delineate Natural Landscape Blocks according to specific rules that varied among the State's diverse ecoregions (Hickman 1993). Ecoregion-specific rules (e.g., using different Ecological Condition Index thresholds to distinguish Natural Landscape Blocks) were necessary to account for great inter-regional variation in degrees of habitat loss, habitat fragmentation, and land protection throughout the State. They allowed for more appropriate discrimination of those areas important to supporting biological diversity in need of connectivity in and between regions. For example, a single, state-wide Ecological Condition Index threshold that would adequately discriminate areas to be connected in the Sierra Nevada or Mojave Desert would eliminate almost all land in the Great Central Valley or San Francisco Bay Area from consideration, including important habitat areas that deserve connectivity. On the other hand, a statewide threshold that adequately discriminated Natural Landscape Blocks in the Central Valley and Bay Area would coalesce the entire Sierra Nevada and Desert regions into a single, huge block. To further account for within-ecoregion variability in degree of habitat degradation and fragmentation, we also differentiated the Bay Area[10] from the Southern Central Coast Ecoregion, and the Northern Sierra Nevada from the Southern Sierra Nevada Ecoregion[11].

Ultimately, all GAP status 1 or 2 lands were included as potential Natural Landscape Blocks, along with any areas meeting the following criteria (arranged from most inclusive to least inclusive by ecoregion, Figure 2.4)[12]:

- *South Coast, Bay Area, Great Central Valley, Northern Sierra Nevada:*
  - ECI > 70 *OR*
  - ECI > 51 AND High Biological Value
- *Modoc Plateau:*
  - ECI > 95 OR
  - ECI > 71 AND High Biological Value
- *North Coast, Southern Central Coast:*

[10] The Bay Area includes those portions of the following counties falling within the greater Central Coast Ecoregion: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, and Solano.

[11] The Northern Sierra Nevada included portions of all Counties from Calavera north falling within the greater Sierra Nevada Ecoregion.

[12] These thresholds were established by visual evaluation of mapped results produced using alternative criteria, applied iteratively, to each ecoregion. The team strived to balance inclusiveness versus discrimination ability of the resulting maps, based on expert opinion of team members familiar with the ecoregions.

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FIGURE 2.2.
GAP CONSERVATION STATUS
GAP Category 1 or 2
Ecoregions
0 37.5 75 150 225
Kilometers
0 25 50 100 150
Miles
1:5,300,000

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 2.3.
HIGH BIOLOGICAL VALUE
High Biological Value
Ecoregions
0 37.5 75 150 225
Kilometers
0 25 50 100 150
Miles
1:5,300,000

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 2.4.
ECOREGIONS FOR NLB DELINEATION
South Coast, Bay Area, Great Central Valley, Northern Sierra Nevada
Modoc Plateau
North Coast, Southern Central Coast
Mojave and Sonoran Deserts, Southern Sierra Nevada
Ecoregions
Modoc Plateau
North Coast
Northern Sierra Nevada
Great Central Valley
Southern Sierra Nevada
Bay Area
Southern Central Coast
Mojave Desert
South Coast
Sonoran Desert
0 37.5 75 150 225
Kilometers
0 25 50 100 150
Miles
1:5,300,000

- ECI > 95

- *Mojave and Sonoran Deserts and Southern Sierra Nevada:*
  - ECI > 95 AND High Biological Value

Application of these rules resulted in thousands of potential Natural Landscape Blocks, many of which were too small to be reasonably assessed at the statewide level. Consequently, preliminary blocks < 2,000 acres in size were eliminated as potential Natural Landscape Blocks statewide. Remaining blocks were aggregated if within one kilometer of each other by subsuming the intervening gap using the ArcGIS Aggregate Polygons tool (ESRI 2008). Portions of blocks within 50 m of major and secondary roads were removed to recognize the potential for highways to fragment habitat. This action split many large Natural Landscape Blocks into multiple smaller ones. Any resulting blocks ≥ 2,000 acres formed the final set of 850 Natural Landscape Blocks (Figure 2.5). Of these 850 Natural Landscape Blocks, 458 were 2,000 to 10,000 acres, and 392 were > 10,000 acres.

2.2. Determining Which Natural Landscape Blocks To Connect

Once the Natural Landscape Blocks were delineated, the following rules were used to select pairs or constellations of Natural Landscape Blocks that should be connected. These rules distinguish between Essential Connectivity Areas that were subsequently delineated using least-cost corridor analysis (see Section 2.3.2.) and Road Fragmentation Areas, which involve Natural Landscape Blocks separated only by a road, for which least-cost modeling is neither necessary nor appropriate (see Section 2.2.3). Regardless of the nature of the areas being connected, pairs of blocks to be connected were first represented on maps as line segments, referred to below as "sticks." Sticks were placeholders showing which Natural Landscape Blocks needed to be connected using least-cost corridor models or where road fragmentation measures need to be developed (in the event the Natural Landscape Blocks are separated only by a road).

2.2.1. Rules for Drawing Sticks for Essential Connectivity Areas

Sticks represent the need to connect two or more Natural Landscape Blocks with an Essential Connectivity Area. The location of a stick did not indicate the location of the Essential Connectivity Area; sticks were placeholders indicating which Natural Landscape Blocks needed to be connected using least-cost corridor modeling.

1. Sticks were drawn to connect the centroids[13] of Natural Landscape Blocks that were ≥ 10,000 acres in size and that were not entirely edge-affected (entirely edge-affected blocks are those where all portions are < 1 km from the block's edge)[14]. In the

[13] We use centroids of the Natural Landscape Blocks as the termini for least-cost corridor modeling because (1) this is repeatable and (2) it provides the least-cost corridor model sufficient room to roam between landscape blocks. Using block edges can constrain the least-cost corridor such that it may simply identify the shortest route between the facing Natural Landscape Block edges, potentially omitting more functional (lower -cost) routes.

[14] This procedure eliminated long, semi-linear areas < 2 km wide as Natural Landscape Blocks. Many of these were later incorporated into least-cost corridors between larger, less edge-effected blocks.

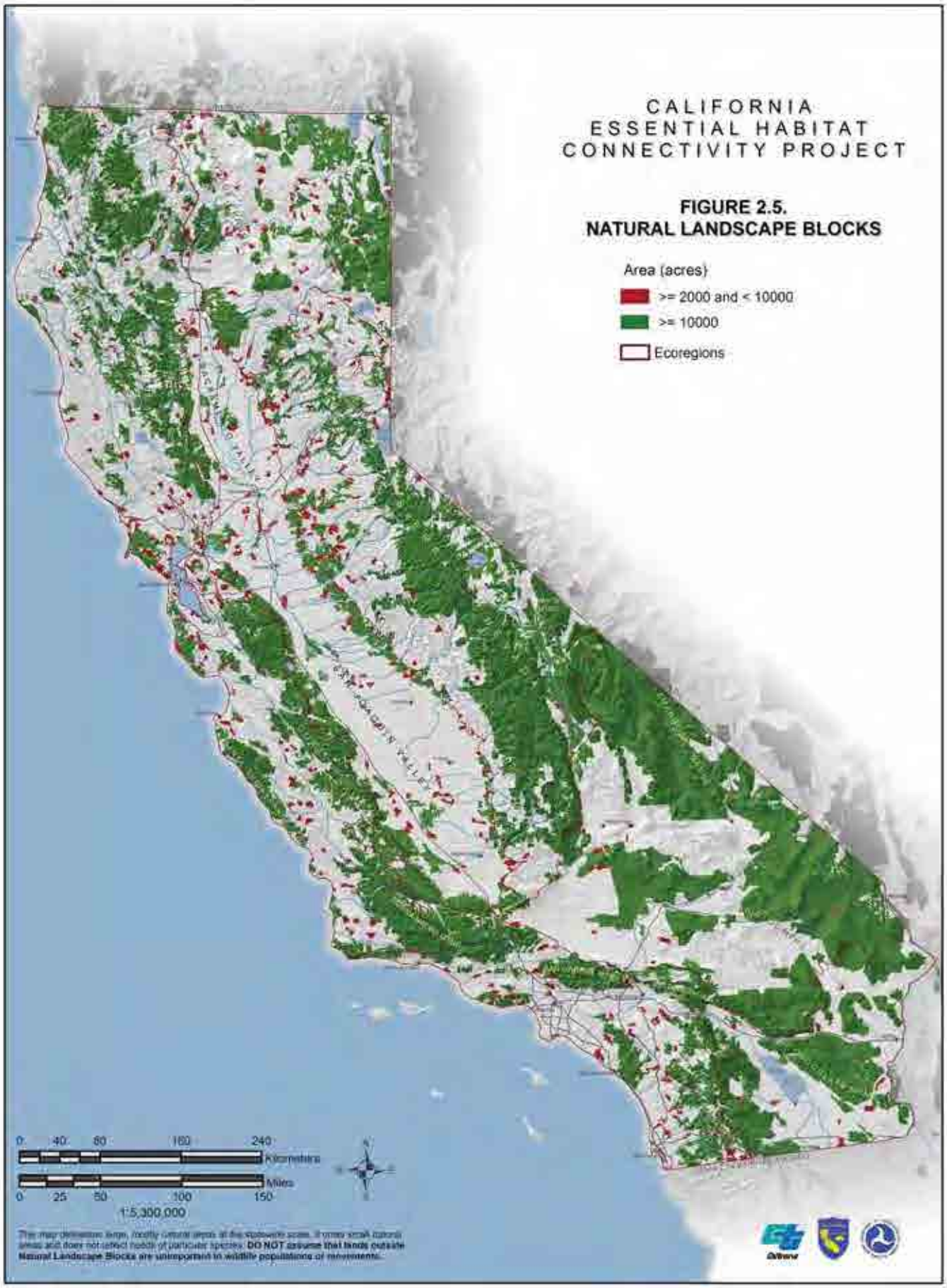
CALIFORNIA
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FIGURE 2.5.
NATURAL LANDSCAPE BLOCKS
Area (acres)
>= 2000 and < 10000
>= 10000
Ecoregions
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000
DO NOT assume that lands outside
Natural Landscape Blocks are unimportant to wildlife populations or movements.

Central Valley, Bay Area, Northern Sierra Nevada, and South Coast ecoregions, sticks were also drawn to Natural Landscape Blocks 2,000 to 10,000 acres or entirely edge-affected, if the blocks met all other criteria for drawing sticks.

2. No stick could represent an Essential Connectivity Area that would have to cross > 1 km of open water or > 1.5 km of urban land. (Note that a *stick* may cross open water or urban land if it is feasible for the modeled Essential Connectivity Area to avoid crossing such areas.)
3. Each Natural Landscape Block was connected to its nearest neighbor (where nearness was defined edge to edge). Where the nearest neighbor was > 15 km away, the resistance surface (see Section 2.3.1) between the Natural Landscape Blocks had to be dominated by values < 15 (on a scale of 1 to 25, as described in Section 2.3.1) [15].
4. Each Natural Landscape Block was also connected to its second nearest neighbor if the second neighbor was < 15 km away (edge to edge) or < 5 km across high-resistance (resistance > 15) areas, such as urban or agricultural landscapes.
5. A group of two or more Natural Landscape Blocks connected by sticks is called a *constellation*. Once all constellations were created by the above rules, each constellation was connected to its nearest neighboring constellation, if it was not already connected, starting with the smallest constellation.

2.2.2. Rules for Removing and Consolidating Sticks[16]

Application of the preceding rules resulted in many hundreds of Essential Habitat Connectivity Areas that would need to be modeled using least-cost corridor methods, which was prohibitive given project constraints. We therefore derived and applied (manually, using expert judgment) the following rules to reduce the total number of model runs by eliminating some redundant sticks and consolidating chains of sticks into a single spanning stick.

1. When a Natural Landscape Block was connected to two or more Natural Landscape Blocks by sticks or chains of sticks, redundant sticks that were markedly inferior were removed. "Inferior" was defined as a potential connectivity area that would have to cross at least twice as much high-resistance (> 15) land as the better alternative, or that would be constrained by existing land uses to be less than half the width of the better alternative. We retained redundant connections where they were of roughly equal quality.

[15] This determination was done by visual inspection and was generally quite straightforward: In most cases, intervening lands were either mostly natural landcovers (low resistance) or mostly non-natural land covers (high resistance).

[16] The following rules for removing or consolidating sticks are specifically intended to limit least-cost corridor modeling to meaningful and non-redundant locations. Many sticks "removed" by these rules were later captured within least-cost corridors for other sticks.

2. Where multiple sticks connected three or more Natural Landscape Blocks in a fairly linear configuration ("stepping stones"), they were consolidated by user judgment as one stick spanning the entire group between the centroids of the two farthest blocks (Figure 2.6), unless a least-cost corridor model between the two farthest blocks would be unlikely to connect all blocks in the group (in which case sticks were still drawn independently between the nearest-neighbor pairs as described above).

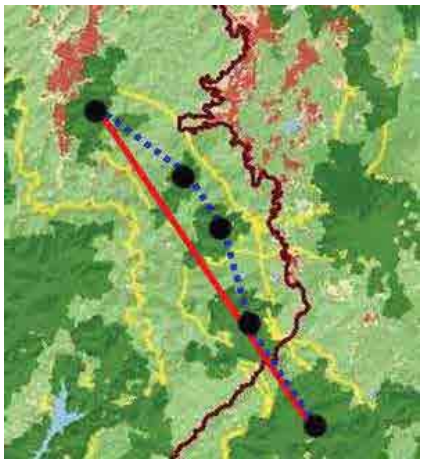

Figure 2.6. Use of a spanning stick (red) to consolidate a chain of sticks (blue) connecting multiple Natural Landscape Blocks (dark green). A single least-cost corridor (yellow) between the centroids (black) of the end blocks captures the intervening blocks.

2.2.3. Designating Road Fragmentation and Adjacent State Connectivity Areas

Road fragmentation sticks were used where the facing edges of two Natural Landscape Blocks were separated only by a road, railroad, or similar linear feature that may represent a barrier to wildlife movement. In these cases, there was no need for least-cost corridor modeling. Road fragmentation is addressed in Chapter 6 with approaches for identifying where road-crossing structures or other mitigation actions may be recommended based on future, more local-scale analyses, and design criteria for such mitigation actions.

Interstate connections were also indicated using sticks to recognize the need for connectivity into neighboring states (Arizona, Nevada, and Oregon). Interstate sticks connect centroids of California Natural Landscape Blocks to the centroids of GAP 1 or 2 lands within 100 km of the border in neighboring states. However, no least-cost corridor modeling or other attempts to delineate interstate Essential Connectivity Areas were performed for interstate sticks. Rather, interstate sticks were depicted as placeholders for future efforts, ideally in collaboration with those states.

Figure 2.7 illustrates the sticks resulting from the above rules, with Essential Connectivity Area sticks, Road fragmentation sticks, and Interstate sticks shown in different colors.

2.3. Delineating Essential Connectivity Areas

Essential Connectivity Area polygons were created between pairs of Natural Landscape Blocks using least-cost corridor models (Singleton et al. 2002) run on a resistance surface

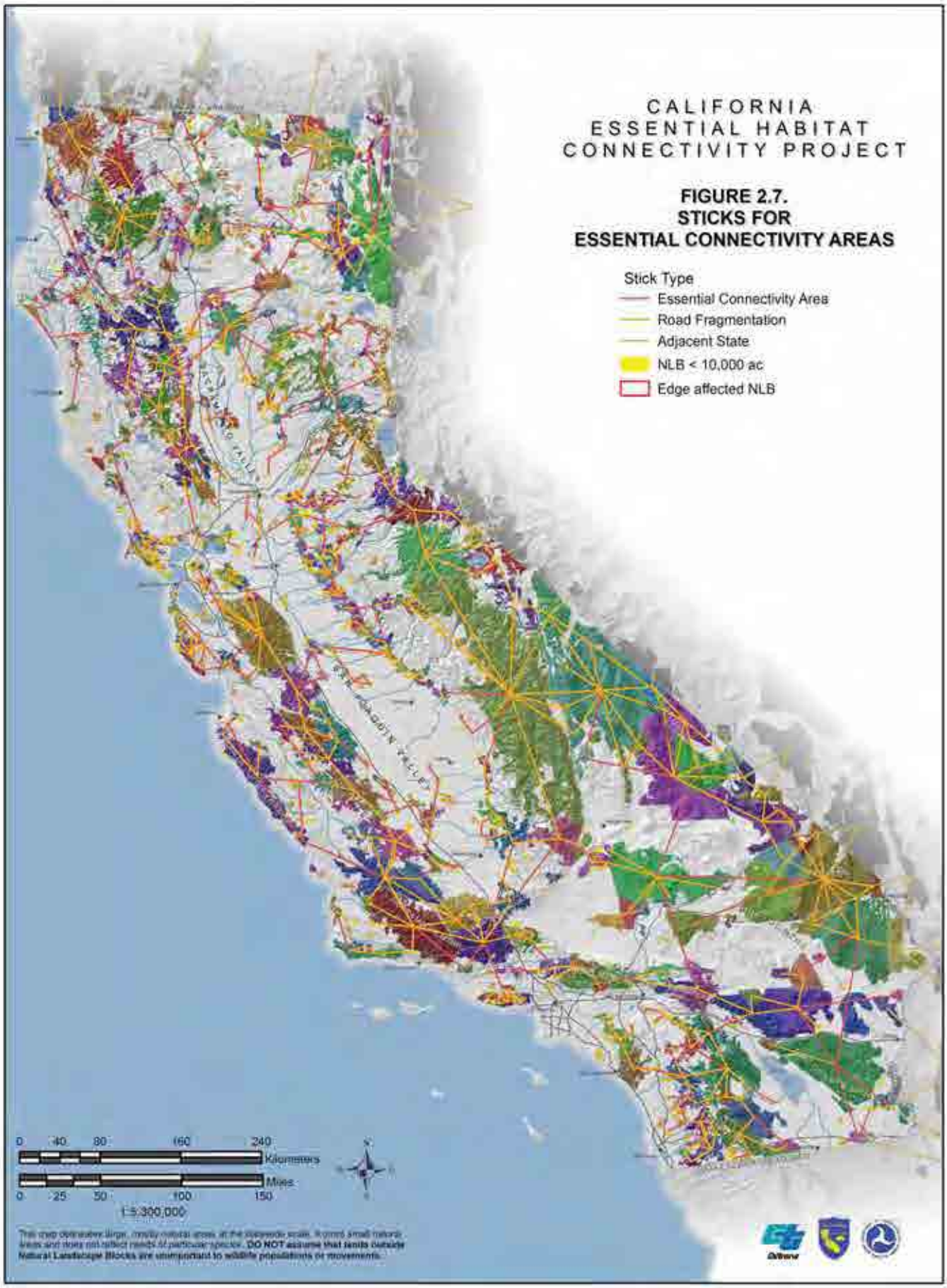
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FIGURE 2.7.
STICKS FOR
ESSENTIAL CONNECTIVITY AREAS
Stick Type
Essential Connectivity Area
Road Fragmentation
Adjacent State
NLB < 10,000 ac
Edge affected NLB
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000
This map delineates large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect needs of particular species. DO NOT assume that lands outside Natural Landscape Blocks are unimportant to wildlife populations or movements.

that represents the relative resistance of the landscape to ecological movements. These steps are detailed below.

2.3.1. Creating the Resistance Surface

Least-cost corridor models (Singleton et al. 2002) use a "resistance surface" as the primary input. The resistance surface represents the per-pixel cost of movement across the landscape for an ecological movement of interest (e.g., species migration or gene flow)[17]. However, for this statewide modeling effort, it was not possible to model movements of particular focal species or genes across the landscape. Therefore, we used a resistance layer based primarily on land-cover naturalness—as a proxy representing, very broadly, overall resistance of the landscape to ecological flows—under the assumption that less human-modified areas are less resistant to most ecological movements of interest. The resistance layer therefore emphasizes landscape naturalness, modified to assign slightly lower resistance to lands that are protected against habitat conversion and managed for ecological values.

Resistance values for landcover type were assigned based on expert opinion of landcover permeability to ecological flows and ranged from 0 (for natural landcover types) to 20 (for completely urbanized landcover types) (Table 2.1, Figure 2.8). Land protection status was given a separate score from 0 for GAP 1 lands (e.g., Wilderness Areas and Ecological Reserves, which are managed for ecological values and have the highest protection from conversion) increasing linearly to 4 for GAP 4 lands (which generally have no protection from conversion) (Table 2.2, Figure 2.9). Thus, the landcover score was weighted four times as much as the land protection score in determining total resistance. The final resistance surface was a 30-m grid with pixel scores ranging from 1 to 25 (Resistance = Landcover Score + Protection Score +1)[18]. Because this scaling ranges only from 1 to 25, it does not allow the flexibility to model situations with extremely high resistance to ecological flows. For example, Shirk (2009) used circuit theory to investigate resistance to gene flow for mountain goats (*Oreamnos americanus*) in Washington State and found resistance across a major highway to be on the order of one thousand times greater than resistance elsewhere. Our conservative scaling may therefore overestimate permeability for focal species and ecological flows that are highly sensitive to highways, urban areas, or other potential impediments to movement. Finer-resolution analyses at local and regional scales (see Chapters 4-6) should select resistance scales appropriate to the ecological flows of interest, and should consider empirical evidence, such as measured movement rates or gene-flow rates, if available.

[17] Unfortunately, resistance has no simple biological interpretation. For instance, a resistance of 10 does not necessarily indicate that the energetic costs or mortality risks of travel are 10 times than those for a resistance of 1. Beier et al. (2008) name this the "subjective translation problem," and explained that it would be resolved only when resistance estimates are derived from data on animal movement or gene flow.

[18] The lowest possible resistance (or cost of movement) score must be 1, not 0, to avoid the untenable assumption of zero cost of movement and to avoid arithmetic artifacts, such as multiplying distance by zero when calculating cumulative costs within the least-cost corridor.

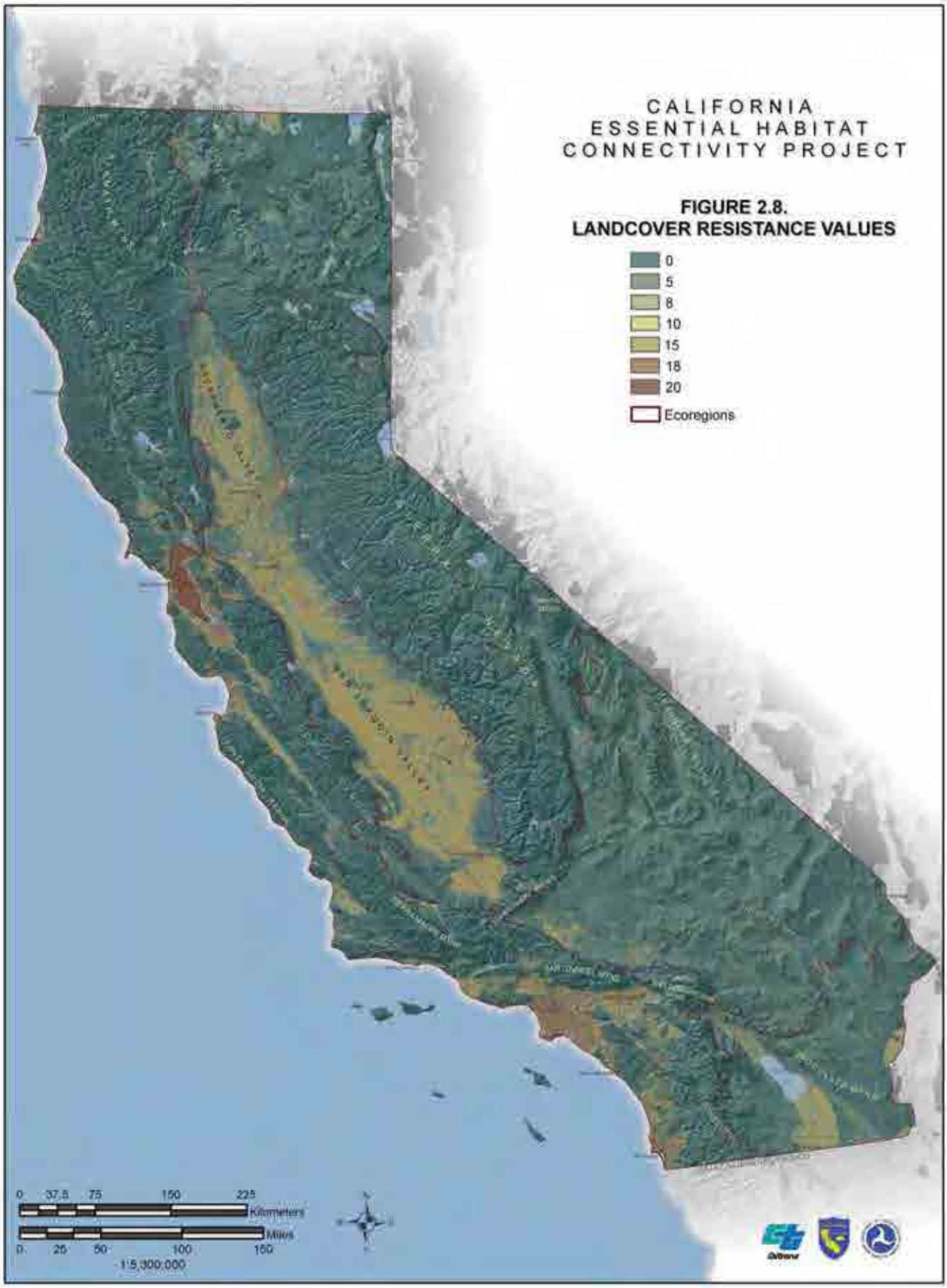
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FIGURE 2.8.
LANDCOVER RESISTANCE VALUES
0
5
8
10
15
18
20
Ecoregions
0 37.5 75 150 225
Kilometers
0 25 50 100 150
Miles
1:5,300,000

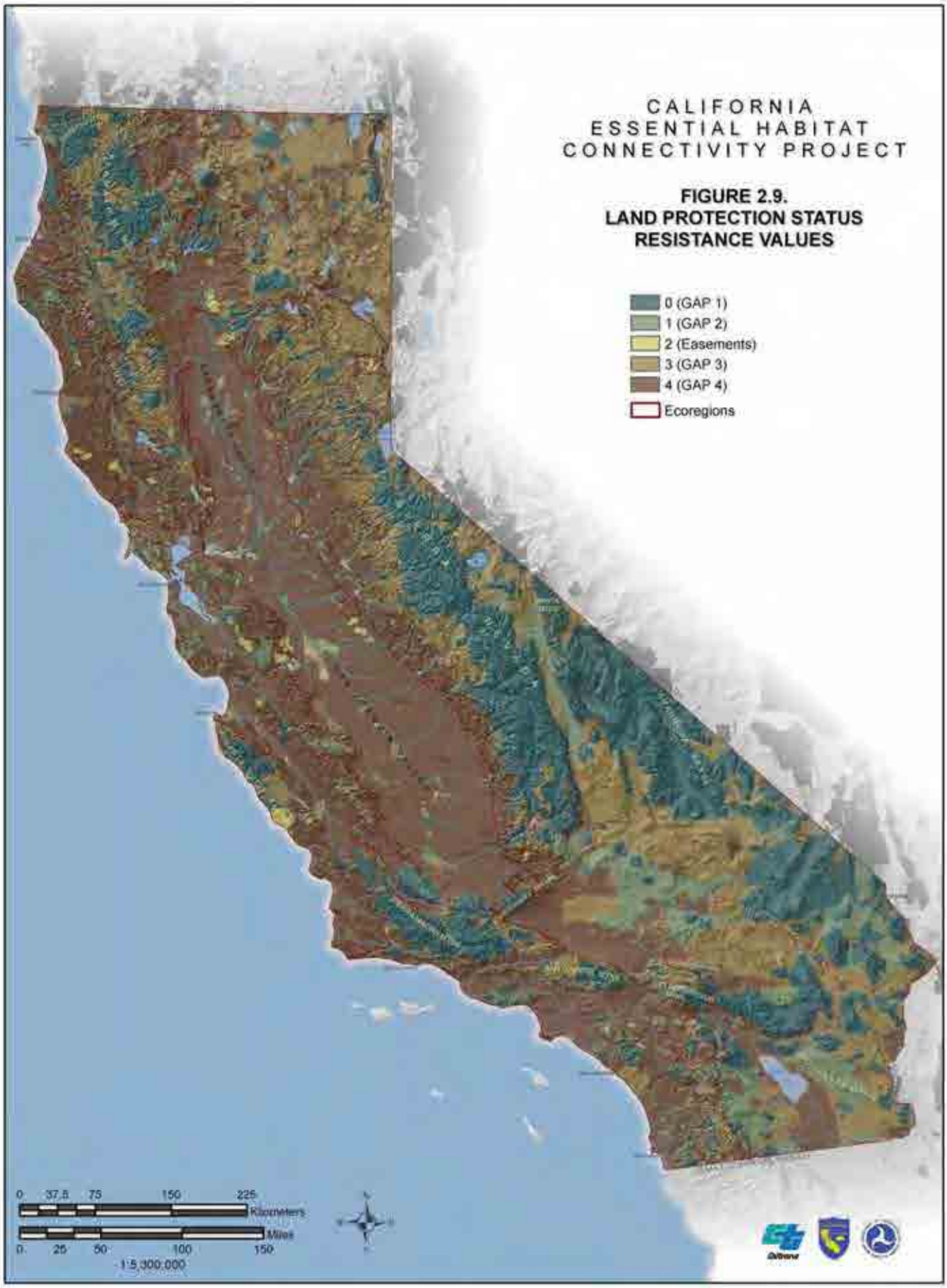
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FIGURE 2.9.
LAND PROTECTION STATUS
RESISTANCE VALUES
0 (GAP 1)
1 (GAP 2)
2 (Easements)
3 (GAP 3)
4 (GAP 4)
Ecoregions
0 37.5 75 150 225
Kilometers
Miles
0 25 50 100 150
1:5,300,000

Table 2.1. Land Cover Costs

Cost	Class	Land Cover
20	Developed, High Intensity	Developed, High Intensity
20	Open Water	Open Water
20	Primary/Secondary Roads	Primary Roads (TIGER 2007), Secondary Roads/Ramps (TIGER 2007)
18	Developed, Medium Intensity	Developed, Medium Intensity
18	Local Roads and Railroads	Local Roads (TIGER 2007), Railroads (TIGER 2007)
15	Row Crops	Cropland (1998 GAP), Cultivated Crops, Irrigated Row and Field Crops (1998 GAP)
15	Vineyard	Orchard and Vineyard (1998 GAP), Vineyard (1998 GAP)
10	Developed, Low Intensity	Developed, Low Intensity
10	Developed, Open Space	Developed, Open Space
10	Orchard	Deciduous Orchard (1998 GAP), Evergreen Orchard (1998 GAP)
8	Grain/Hay/Pasture	Dryland Grain Crops (1998 GAP), Hay/Pasture, Irrigated Hayfield (1998 GAP), Pasture (1998 GAP)
5	Barren	Central California Coast Ranges Cliff and Canyon, Coulmbia Plateau Ash and Tuff Badland, Inter-Mountain Basins Active and Stabilized Dune, Inter-Mountain Basins Cliff and Canyon, Inter-Mountain Basins Playa, Inter-Mountain Basins Shale Badland, Inter-Mountain Basins Volcanic Rock and Cinder Land, Inter-Mountain Basins Wash, Klamath-Siskiyou Cliff and Outcrop, Mediterranean California Alpine Bedrock and Scree, Mediterranean California Coastal Bluff, Mediterranean California Northern Coastal Dune, Mediterranean California Serpentine Barrens, Mediterranean California Southern Coastal Dune, North American Alpine Ice Field, North American Warm Desert Active and Stabilized Dune, North American Warm Desert Bedrock Cliff and Outcrop, North American Warm Desert Pavement, North American Warm Desert Playa, North American Warm Desert Volcanic Rockland, North Pacific Volcanic Rock and Cinder Land, Sierra Nevada Cliff and Canyon, Southern California Coast Ranges Cliff and Canyon, Temperate Pacific Freshwater Mudflat
5	Harvested Forests	Harvest Forest- Tree Regenerated, Harvested Forest- Shrub Regenerated, Harvested Forest-grass regeneration
5	Introduced Vegetation	Introduced Annual and Biennial Forbland, Introduced Upland Vegetation - Annual and Perennial Grassland, Introduced Upland Vegetation – Treed, Introduced Upland Vegetation -Perennial Grassland
5	Quarries/Strip Mines/Gravel Pits	Quarries/Strip Mines/Gravel Pits
5	Recently Burned	Recently Burned- Forest, Recently Burned- Grassland, Recently Burned- Shrubland
0	Forest and Woodland	California Coastal Closed-Cone Conifer Forested and Woodland, California Coastal Redwood Forest, California Montane Jeffrey Pine-(Ponderosa Pine) Woodland, Central and Southern California Mixed Evergreen Woodland, Columbia Plateau Western Juniper Woodland and Savanna, East Cascades Oak-Ponderosa Pine Forest and Woodland, Great Basin Pinyon-Juniper Woodland, Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland, Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland, Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland, Klamath-Siskiyou Lower Montane Serpentine Mixed Conifer Woodland, Klamath-Siskiyou Upper Montane Serpentine Mixed Conifer Woodland, Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland, Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland, Mediterranean California Mesic Mixed Conifer Forest and Woodland, Mediterranean California Mesic Serpentine Woodland and Chaparral, Mediterranean California Mixed Evergreen Forest, Mediterranean California Mixed Oak Woodland, Mediterranean California Red Fir Forest, Mediterranean California Subalpine Woodland, North Pacific Broadleaf Landslide Forest and Shrubland, North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland, North Pacific Hypermaritime Sitka Spruce Forest, North Pacific Lowland Mixed Hardwood Conifer Forest and Woodland, North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest, North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest, North Pacific Mountain Hemlock Forest, North Pacific Oak Woodland, North Pacific Wooded Volcanic Flowage, Northern California Mesic Subalpine Woodland, Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest, Northern

		Rocky Mountain Ponderosa Pine Woodland and Savanna, Rocky Mountain Aspen Forest and Woodland, Rocky Mountain Lodgepole Pine Forest, Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland, Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland, Rocky Mountain Poor Site Lodgepole Pine Forest and Woodland, Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland, Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland, Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland, Sierran-Intermontane Desert Western White Pine-White Fir Woodland
0	Herbaceous	California Central Valley and Southern Coastal Grassland, California Mesic Serpentine Grassland, California Northern Coastal Grassland, Inter-Mountain Basins Semi-Desert Grassland, Mediterranean California Alpine Dry Tundra, Mediterranean California Subalpine Meadow, North Pacific Alpine and Subalpine Dry Grassland, North Pacific Montane Grassland, Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland, Rocky Mountain Subalpine-Montane Mesic Meadow
0	Shrubland	Apacherian-Chihuahuan Mesquite Upland Scrub, California Maritime Chaparral, California Mesic Chaparral, California Montane Woodland and Chaparral, California Xeric Serpentine Chaparral, Columbia Plateau Scabland Shrubland, Great Basin Semi-Desert Chaparral, Great Basin Xeric Mixed Sagebrush Shrubland, Inter-Mountain Basins Big Sagebrush Shrubland, Inter-Mountain Basins Mixed Salt Desert Scrub, Mediterranean California Alpine Fell-Field, Mogollon Chaparral, Mojave Mid-Elevation Mixed Desert Scrub, North Pacific Avalanche Chute Shrubland, North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field and Meadow, North Pacific Montane Shrubland, Northern and Central California Dry-Mesic Chaparral, Northern California Coastal Scrub, Northern Rocky Mountain Montane-Foothill Deciduous Shrubland, Sonora-Mojave Creosotebush-White Bursage Desert Scrub, Sonora-Mojave Mixed Salt Desert Scrub, Sonora-Mojave Semi-Desert Chaparral, Southern California Coastal Scrub, Southern California Dry-Mesic Chaparral
0	Steppe and Savanna	California Central Valley Mixed Oak Savanna, California Coastal Live Oak Woodland and Savanna, California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna, Columbia Plateau Low Sagebrush Steppe, Columbia Plateau Steppe and Grassland, Inter-Mountain Basins Big Sagebrush Steppe, Inter-Mountain Basins Juniper Savanna, Inter-Mountain Basins Montane Sagebrush Steppe, Inter-Mountain Basins Semi-Desert Shrub-Steppe, Klamath-Siskiyou Xeromorphic Serpentine Savanna and Chaparral, Southern California Oak Woodland and Savanna, Willamette Valley Upland Prairie and Savanna
0	Wetland/Riparian	California Central Valley Riparian Woodland and Shrubland, Columbia Basin Foothill Riparian Woodland and Shrubland, Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe, Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland, Inter-Mountain Basins Alkaline Closed Depression, Inter-Mountain Basins Greasewood Flat, Mediterranean California Eelgrass Bed, Mediterranean California Foothill and Lower Montane Riparian Woodland, Mediterranean California Serpentine Foothill and Lower Montane Riparian Woodland, Mediterranean California Subalpine-Montane Fen, North American Arid West Emergent Marsh, North American Warm Desert Riparian Mesquite Bosque, North American Warm Desert Riparian Woodland and Shrubland, North American Warm Desert Wash, North Pacific Lowland Riparian Forest and Shrubland, North Pacific Montane Riparian Woodland and Shrubland, Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland, Rocky Mountain Alpine-Montane Wet Meadow, Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland, Rocky Mountain Subalpine-Montane Riparian Shrubland, Rocky Mountain Subalpine-Montane Riparian Woodland, Temperate Pacific Freshwater Emergent Marsh, Temperate Pacific Subalpine-Montane Wet Meadow, Temperate Pacific Tidal Salt and Brackish Marsh

Table 2.2. Protection Status Resistances

Resistance	GAP Protection Status
0	GAP1
1	GAP2
2	Conservation Easements
3	GAP3
4	GAP4

The basis for the landcover layer was the 2008 California landcover (California GAP Analysis 2008, 30-m resolution) modified by transportation features. Because the GAP 2008 layer lacks the detail for agricultural classes of the old California GAP layer (1998), we used the more detailed agricultural classes (irrigated row and field crops, dryland grain crops, irrigated hayfield, deciduous orchard, evergreen orchard, orchard and vineyard, vineyard) from the older GAP layer instead of the "cultivated crops" class in the new layer (Figure 2.10). Transportation features representing secondary roads and ramps, local roads, and railroads (from 2007 TIGER data, U.S. Census Bureau) were converted separately to 30-m grids. Primary roads were buffered by 25 m before conversion to a 30-m grid. The grids of the four road types were combined into one, giving priority to roads in this order if they overlapped: primary, secondary/ramps, local, and rails. The resulting transportation grid was merged into the landcover grid, overriding all landcovers except developed, medium intensity, and developed, high intensity (Figure 2.11).

2.3.2. Least-cost Corridor Modeling

Once the resistance layer was derived, a least-cost corridor analysis was conducted between the centroids of each pair of Natural Landscape Blocks to be connected. The analysis extent was defined by creating a 5-km buffer around the feature envelope[19] of both Natural Landscape Blocks in a pair. The cost-weighted distance was calculated from each of the two centroids for each pixel in the analysis extent. The two centroid-specific outputs were then summed to define the least-cost surface. The continuous surface output was then sliced into equal-interval percentages to define the least-cost corridor.

The top 5% least-cost corridor (i.e., the lowest-cost 5% of pixel values in the analysis window) was used to define the Essential Connectivity Areas. This 5% least-cost corridor appeared to reasonably approximate the size and shape of linkage design polygons delineated by focal species methods for the South Coast Missing Linkages project (Beier et al. 2006), and appeared to represent a fairly inclusive, but biogeographically justifiable polygon for most Essential Connectivity Areas at this state-wide scale.

2.3.3. Refining the Least-cost Polygons

Due to the close proximity of some Natural Landscape Blocks, overlap of analysis extents that shared one Natural Landscape Block, and the variable sizes of the analysis extents, there were some Essential Connectivity Areas that were completely subsumed by others. In these few cases, the smaller Essential Connectivity Area that was completely included within a larger one was removed from the final output.

[19] A feature envelope is a rectangular area determined by the maximum and minimum x and y coordinates enclosing a feature of interest, in this case the pair of Natural Landscape Blocks.

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FIGURE 2.10.
LANDCOVER TYPES IN
RESISTANCE SURFACE
Barren
Quarries/Strip Mines/Gravel Pits
Developed, High Intensity
Developed, Medium Intensity
Developed, Low Intensity
Developed, Open Space
Grain/Hay/Pasture
Ecoregions
Row Crops
Orchard
Vineyard
Recently Burned
Introduced Vegetation
Harvested Forests
Natural Land Covers
Open Water
0 37.5 75 150 225
Kilometers
0 25 50 100 150
Miles
1:5,300,000

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FIGURE 2.11.
FINAL LANDCOVER TYPES IN
RESISTANCE SURFACE
Barren
Quarries/Strip Mines/Gravel Pits
Developed, High Intensity
Developed, Medium Intensity
Developed, Low Intensity
Developed, Open Space
Primary and Secondary Roads
Local Roads, Railroads
Ecoregions
Grain/Hay/Pasture
Row Crops
Orchard
Vineyard
Recently Burned
Introduced Vegetation
Harvested Forests
Natural Land Covers
Open Water
0 37.5 75 150 225
Kilometers
Miles
0 25 50 100 150
1:5,300,000

For cases where least-cost corridor analyses were run on “spanning sticks” across three or more Natural Landscape Blocks (see Section 2.2.2) and an internal landscape block completely spanned the 5% least-cost corridor, the least-cost polygon was segmented into two Essential Connectivity Areas at the centroid of the spanning Natural Landscape Block, which then became a terminal block.

Because each analysis was run from centroid to centroid, instead of from edge to edge of the Natural Landscape Block pair, a portion of the least-cost corridor output occurred within each Natural Landscape Block. To display the Essential Connectivity Areas on a map and describe its characteristics in a meaningful way (Chapter 3), the final boundaries were defined by subtracting the portions of the least-cost corridor output that fell within terminal Natural Landscape Blocks.

2.3.4. Potential Riparian Connection Additions

Potential riparian connections were added using the Statewide 1:100k Routed Hydrography for California dataset (CDFG, Pacific States Marine Fisheries Commission 2003). This data file is a 1:100,000 scale, stream-based routed hydrography covering the entire State of California. Named rivers and streams that were at least 50 miles long were extracted from the dataset and added to Essential Connectivity Maps. These potential riparian connections were added to illustrate the contribution that streams, rivers, and adjacent vegetation can make to both terrestrial and aquatic connectivity. In many parts of the state, such riparian corridors represent the best remaining options for sustaining or improving ecological connectivity.

2.4. Characterizing Natural Landscape Blocks and Essential Connectivity Areas

Each Natural Landscape Block and Essential Connectivity Area is a polygon—that is, a two-dimensional area in map space. Users of this report need data on polygon attributes to describe the biological and physical traits of each polygon, or to make decisions on conservation investments and conservation strategies.

The Essential Habitat Connectivity Maps depict the spatial location and shape of each polygon. To provide users with additional quantitative information on each polygon, we selected 36 biological and physical characteristics (Tables 2.3 and 2.4). Some of these characteristics, such as Ecological Condition Index, protection status, occurrence of wetlands, and occurrence of Critical or essential habitat, were used to define the Natural Landscape Blocks. Other traits, such as landcover, were used to define the resistance-surface layer. Yet other variables, such as length of the Essential Connectivity Area, emerged from our analyses.

We used ArcGIS queries to generate summary statistics (e.g., sum, mean, proportion) for each trait. The statistic used for each characteristic is indicated in Table 2.3. Quantitative metrics, such as area and length, were rounded in recognition of the coarse scale of the analysis and to avoid false appearances of precision. The Natural Landscape Blocks and

Essential Connectivity Areas should be viewed as rough approximations that should be refined by future, finer-scale assessments.

Table 2.4 lists and defines the physical and biological characteristics of Essential Connectivity Areas and Natural Landscape Blocks and lists the data sources for each descriptor. Some of these metrics (such as Ecological Condition Index, protection status, wetlands, and Critical or essential habitat) were used to help define Natural Landscape Blocks, and others (such as landcover, road density, and protection status) were used to define the resistance-surface layer and Essential Connectivity Areas. All of the metrics are potentially useful to describe the polygons, but we urge readers to consider information in the *Limitations* column of the table to avoid over-interpreting the data. Some users and stakeholders may wish to use some of these descriptors to prioritize Essential Connectivity Areas according to their organization's mandates and priorities.

Table 2.3. Statistics used to describe polygons (Natural Landscape Blocks, Essential Habitat Connectivity Areas). The characteristics are defined in Table 2.4.

Statistic	Characteristics for which this statistic was used
Sum across all pixels in the polygon	Area of polygon
Proportion (%) of all pixels in the polygon belonging to a certain class of pixel	Landcover classes (9 broad classes) Land protection classes (4 GAP classes) Rarity-weighed richness hotspots Vernal pool or wetlands Critical or essential habitat BLM Area of Critical Environmental Concern
Mean, range, and standard deviation across all pixels in the polygon	Ecological Condition Index Number of terrestrial vertebrate species whose range overlaps 10-mi^2 (25.9-km^2) hexagons within the NLB or ECA Elevation Elevation range
Line length	Shortest straight line between edges of NLBs within an ECA Length of least cost path within ECA
Count and List	Ecoregions Ecoregion subsections Counties Watershed
Count only	Number of CNDDB special status animal or plant taxa ESA-listed species with Critical Habitat in the polygon ESA-listed species with essential habitat in the polygon Number of times the polygon is intersected by major or secondary roads
Density (km per km^2)	Major roads Secondary roads
Elevation profile	A plot of elevation against distance along the least-cost path between the centroids of the two NLBs

Table 2.4. Definitions, data sources, limitations, and suggested interpretations of metrics related to Natural Landscape Blocks and Essential Connectivity Areas. The final column lists the acronym used in the accompanying appendices to this Report.

	Descriptor	Data Source	Limitations and Suggested Interpretation	Acronym
Identifier	Unique Number for the NLB or ECA			ID
	Name for the NLB or ECA		NLB names	ECA_Name NLB_Name
Landform	Elevation profile (plot of elevation versus distance) along the least-cost path between NLB centroids	Digital Elevation Model	A visual representation of landform (e.g. high plateau, steep mountains, low plains) in the two NLBs (right and left ends of graph) and ECA (center of graph).	Not applicable
	Mean, Min, Max, and Standard Deviation of Elevation	Digital Elevation Model		elev_MEAN elev_MIN elev_MAX elev_STD
	Elevation Range: difference between minimum and maximum elevation	Digital Elevation Model		elev_range
Ecological Condition	Mean Ecological Condition Index, re-scaled to 0-100; see *Section 2.1.1* for details	Davis et al. (2003, 2006)	Some polygons in urban areas have false values of zero, usually because housing density was calculated for Census 2000 Blocks. When a heavily populated Census Block extended into unpopulated natural areas, all pixels were assigned a value exceeding the threshold mean value of 1 house/2 hectares (ha). We advise users to disregard any ECI value < 51 for NLBs adjacent to urban areas.	Mn_integ
	Standard deviation of Ecological Condition Index	Based on variation among pixels within an NLB or ECA		Std_integ

Polygon Area	Area in acres	Calculated in GIS based on number of 1-ha (2.49-acre) pixels in ECA or NLB	Multiply acres by 0.4047 to determine area in ha; divide ha by 100 to determine area in km^2	AREA_acres
Essential Connectivity Area	Identifying numbers of NLBs connected by the ECA			pointA pointB
	List of NLBs (other than the ECA termini) that partially intersect the ECA but do not span ECA width		These NLBs are also served by the ECA	NLB_ln
	Length of shortest straight line within the ECA between edges of NLBs (m)	Measured in GIS		Min_lgth
	Length of least cost path within Essential Connectivity Area (m)	Measured in GIS, based on least-cost model		LCP_lgth
Protection Status	Percent protected as GAP 1, GAP2, GAP3 or easements	CPAD (2009) CBI PAD (2009) SCW Protected Lands (2008) Easements: GreenInfo Network (2009b)	GAP1: permanent protection of natural landcover and mandated plan to maintain disturbance events. GAP2: permanent protection of natural landcover, but uses may degrade quality or suppress natural disturbance. GAP3: permanent protection of most natural landcover, but logging or mining permitted. GAP4: no protection of natural habitat.	Pc_protect
	Percent protected as GAP1, GAP2, or easements			Pc_gap12e
	Percent protected as GAP3			Pc_gap3
	Percent in private, unprotected status			Pc_privunp

Species diversity	Mean number of amphibians, reptiles, mammals, and birds whose range overlaps each 10-mi^2 (25.9-km^2) hexagon	CDFG (2008) http://www.dfg.ca.gov/biogeodata/cwhr/ California Wildlife Habitat Relationships hexagon range maps	Suitable habitat may not be present in every hexagon throughout a species' range. This probably overestimates the number of species in each hexagon.	Mn_sprich
	Standard deviation of number of species per CWHR hexagon			Std_sprich
	Number of special status plant taxa (species or subspecies or varieties) occurring in polygon according to the California Natural Diversity Database (CNDDB) point data	http://www.dfg.ca.gov/biogeodata/cnddb/	CNDDB includes only positive occurrences; absence of records in a polygon does not mean taxon is absent. All records presumed extant, regardless of date, unless otherwise noted in CNDDB.	CNDDB_plant_count
	Number of special status animal taxa (species or subspecies) in polygon according to CNDDB point data		As for plants.	CNDDB_animal_count
	Percent in amphibian, reptile, mammal, or plant rarity hotspot	Derived by CDFG from Rarity-Weighted Richness Index (CDFG 2003a,b)	These are areas with the highest concentrations of special status range-restricted taxa. (See CDFG 2003a for discussion on the limitations of this index.)	Pc_hotspt

Habitat for listed species	Percent in USFWS-designated Critical Habitat for federally listed species	GIS coverages provided by USFWS	Designation is influenced by economic considerations and land ownership.	pc_crithab
	Number of species with Critical Habitat in the polygon			CritHab_Sp_Count
	Percent essential habitat (% with habitat features essential to survival and recovery of the species, as determined by USFWS prior to consideration of economic impact and land ownership)	GIS coverages provided by USFWS	Habitat considered essential to conservation of a species but not designated as Critical due to economic, legal, or other reasons. Unlike Critical Habitat, essential habitat has no regulatory consequences.	pc_essenthab
	Number of species with essential habitat in the polygon			EssHab_Sp_Count
Wetlands	Percent in wetland or vernal pool	CDFG (1998) CDFG (1997) CDFG (2000) CDFG (2003b) USFWS (2006)		Pc_wtvp
Paved roads	Number of times the ECA is intersected by major roads (primary limited access or interstate, primary US and state highways)	ESRI (2008) was used for all road data	Roads within ECAs may require mitigation actions, to be determined by finer-resolution analyses.	Mjrd_cross
	Density of major roads (km/km^2)	Total length divided by polygon area		Mjrd_dens
	Density of secondary state and county highways (km/km^2)	Total length divided by polygon area	Roads within ECAs may require mitigation actions, to be determined by finer-resolution analyses.	Secrd_dens

Ecoregions	Number of Jepson ecoregions (Calif. has 8 ecoregions)	Hickman (1993)		N_Ecoregs
	List of ecoregions			Ecroregs
	Number of ecoregion subsections (Calif. has 190 subsections)	Miles and Goudey (1998)		N_Subsect
	List of ecoregion subsections		If more than 8 occur in a polygon, the 8 largest are listed.	Subsect
Watersheds	Number of watersheds	California Resources Agency 2004	Any portion of the Hydrological Unit intersects the ECA or NLB.	HU_num
	List of watersheds			HU_name
ACEC	Percent in BLM Areas of Critical Environmental Concern based on the area's biological values (rather than archeological or other values)		ACECs can be designated only on federal land; most are on BLM land.	Pc_blmacec
County	Number of counties			N_Counties
	List of counties			Counties
Landcover	Percent classed as forest and woodland	GAP 2008		PC_FOREST
	Percent classed as shrubland, steppe, or savanna	GAP 2008		PC_SHRUB
	Percent classed as herbaceous	GAP 2008		PC_HERB
	Percent classed as wetland/riparian	GAP 2008	"% wetland or vernal pool" (above) was derived from different data sources and is typically (though not always) larger than the area mapped as wetland in GAP (2008).	PC_WETRIP
	Percent classed as open water	GAP 2008		PC_WATER

	Percent classed as developed (high, medium, and low intensity, and open space such as ball fields, cemeteries, and golf courses)	GAP 2008		PC_DEV
	Percent classed as cultivated crops	GAP 2008		PC_CROP
	Percent classed as hay/pasture	GAP 2008		PC_PASTURE
	Percent classed as barren, harvested forest, introduced vegetation, recently burned, or quarries/strip mines/gravel pits	GAP 2008		PC_OTHER

2.5. Comparing the Essential Connectivity Map to Other Conservation Maps

We compared the Essential Connectivity Map to other applicable conservation data and maps, including various conservation priority map layers provided by members of the Multidisciplinary Team. Once data sets were acquired, they were converted to the appropriate coordinate system and clipped to mainland California as necessary. We calculated area included in polygons of the comparison dataset, calculated areas of overlap with Natural Landscape Blocks and Essential Connectivity Areas, and derived statistics for appropriate attributes within GIS. The following specific data layers were compared to the Essential Habitat Connectivity Map:

- *Habitat Conservation and Natural Community Conservation Plans* (CDFG 2009). Due to tremendous variation among Habitat Conservation Plans and Natural Community Conservation Plans in the nature of mapped polygons, and lack of information on what each polygon means in many plans, only planning area boundaries were overlaid on the Essential Habitat Connectivity Map.
- *USFWS designated Critical Habitat* and *essential habitat* (USFWS 2009). For each species, overlap with the Natural Landscape Blocks and Essential Connectivity Areas was calculated. Critical Habitat includes Final Critical Habitat and Final Critical Habitat (Preliminary); essential habitat includes Excluded Essential Habitat, Excluded Habitat, Exempt from Critical Habitat, Proposed Critical Habitat, Under Review, and Vacated Critical Habitat.
- *Existing California Conservation Network and Other Major Landholders.* Existing conservation areas (California Protected Areas Database version 1.3; CPAD 2009) and Department of Defense Lands and Tribal lands (National Atlas 2005) were

overlaid on the Essential Habitat Connectivity Map. The "Symbology Layer" field in CPAD was used to delineate areas by ownership (e.g. City, County, and NGO) to generate a summary table.

- *California Missing Linkages Project* (Penrod et al. 2001) was compared by overlaying the Missing Linkages arrows over the Essential Habitat Connectivity Map for visual comparison.
- *Functional Habitat Connectivity of the American Marten in Northeastern California* (Kirk and Zielinski in preparation). The marten *(Martes americana)* connectivity map was prepared by the USDA Forest Service for this species of concern that relies on dense, late-seral coniferous forests. The map consists of six least-cost corridor polygons that connect between protected lands that support marten populations or high-value marten habitat, from the central Sierra Nevada to the Oregon border. It represents an interesting opportunity to compare how well our coarse Natural Landscape Blocks and Essential Connectivity Areas, which are not based on particular focal species, may capture habitat blocks and least-cost corridors for a focal species at an ecoregional scale.
- *Wildlands Conservation in the Central Coast Region of California* (Thorne et al. 2002). Overlap with this regional conservation network design was calculated for cores, linkages, and the total network as presented in Thorne et al. (2002).
- *A Potential Regional Conservation Network for the Central Valley Ecoregion* (Huber et al. 2010). "Conservation opportunity areas" and least-cost corridors from this focal-species-based plan (Huber et al. 2010) were compared with the Essential Habitat Connectivity Map.
- *South Coast Missing Linkages Project* (Penrod et al. 2003, Luke et al. 2004, Penrod et al. 2004 a,b, Penrod et al. 2005 a,b,c, and Penrod et al. 2006 a,b,c,d). Local-scale linkage design outlines from this focal-species-based regional plan were compared with the Essential Habitat Connectivity Map.
- *Dispersal and Corridor Models for Desert Bighorn Sheep* (Epps et al. 2007). We overlaid the following features from Epps et al. (2007): population areas; most likely corridors, severed by barriers; and most likely corridors, highest predicted use. For the most likely corridors, the length of each path and the segment length that intersected the Essential Habitat Connectivity Map were calculated. For population areas, area was calculated.
- *California Desert Connectivity Project* (Penrod et al. in preparation). Wildland blocks and targeted linkages for this ongoing regional linkage plan were displayed on a map with the Essential Habitat Connectivity Map for visual comparison.
- *Bay Area Open Space Council's Upland Habitat Goals Project.* MARXAN results from the Bay Area Open Space Council (SF Bay Area Upland Habitat Goals GIS 2009) were used to define Essential and Important areas for conservation in this regional upland network plan. Essential, Important, and total areas overlapping the Essential Habitat Connectivity Map were calculated in order to generate comparison statistics.

- *The Nature Conservancy's Ecoregional Priorities.* Two datasets—mainland California and Cascade Region—were merged and used to calculate overlap of The Nature Conservancy's ecoregional priority sites with the Essential Habitat Connectivity Map, differentiating by Terrestrial, Aquatic, and Marine sites.
- *California Rangeland Conservation Coalition Focus Area Prioritization Map* (Cameron 2007) differentiates Critical and Important Rangelands. Overlap with the Essential Habitat Connectivity Map was calculated for Critical, Important, and total area.
- *Audubon's Important Bird Areas* (National Audubon Society 2008). Important Bird Areas were clipped to mainland. Water bodies were removed using Teale Hydrology (CalAtlas 2003) water polygons (lakes, ponds, bays, estuaries, gulfs, oceans, and seas). Overlap statistics were further delineated by summarizing on geographic region using the "Region" field in the attribute table.

Chapter 3. Results: The Essential Habitat Connectivity Map

Figure 3.1 presents the statewide Essential Habitat Connectivity Map, which illustrates the Natural Landscape Blocks and Essential Connectivity Areas along with placeholder "sticks" for potential interstate connections that should be assessed in the future, in collaboration with neighboring states. Figures 3.2 through 3.9 show each ecoregion in more detail.

3.1. Statewide Summary

The Essential Connectivity Map shows a statewide network of 850 relatively intact Natural Landscape Blocks (ranging in size from 2,000 to about 3.7 million acres) connected by 192 Essential Connectivity Areas (Table 3.1)[20]. There are fewer Essential Connectivity Areas than Natural Landscape Blocks, because each Essential Connectivity Area serves to connect at least two, and as many as 15 Natural Landscape Blocks[21]. Due to the broad, statewide nature of this map, and its focus on connecting very large blocks of mostly protected natural lands, the network omits many areas that are important to biological conservation. The purpose of the map is to focus attention on large areas important to maintaining ecological integrity at the broadest scale. Natural areas excluded from this broad-brush Essential Connectivity Network can therefore not be "written off" as unimportant to connectivity conservation or to sustaining California's natural heritage. Chapters 4 through 6 recommend regional and local analyses to refine the Essential Connectivity Map and identify additional areas important to sustaining ecological connectivity.

Essential Connectivity Area polygons tend to be wide when they connect larger Natural Landscape Blocks (e.g., in the deserts), and narrow where they connect smaller landscape blocks (e.g., in more urbanized regions). This is an artifact of the consistent use of the 5% least-cost corridor to define Essential Connectivity Areas. Because the 5% slice represents the 5% lowest-cost area within the analysis extent comprising each pair of blocks, it is naturally larger when the Natural Landscape Blocks are larger or farther apart. This is reasonable: connections between larger, more distant landscape blocks should be relatively wide. Conversely, smaller Natural Landscape Blocks tend to occur in more developed and highly constrained landscapes (e.g., through narrow bands of undeveloped lands between urbanized areas in the Bay Area or South Coast Ecoregion), and connections between close blocks may not need to be overly wide to accommodate the ecological flows of interest.

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[20] Table 3.1 summarizes the average, minimum, and maximum for each metric across Natural Landscape Blocks and Essential Connectivity Areas. Because of the large number of variables, tables listing all characteristics of the Essential Connectivity Areas and Natural Landscape Blocks are too large to include here. The full results are provided in Appendix B (for Essential Connectivity Areas) and Appendix C (for Natural Landscape Blocks). The data are also available in Excel spreadsheets at http://www.dfg.ca.gov/habcon or http://www.dot.ca.gov/hq/env/bio/program_efforts.htm or GIS tables at http://bios.dfg.ca.gov .

[21] An Essential Connectivity Area can serve numerous landscape blocks as a result of (1) running the least-cost corridor model across a series of Natural Landscape Blocks arrayed more-or-less linearly (using the "spanning stick" rules described in Section 2.2.2) and (2) a least-cost corridor may touch, and therefore serve to connect, a block that was too small (2,000 to 10,000 ac) or edge-effected (< 2 km across) to serve as a terminus for least-cost modeling (see Section 2.2.1).

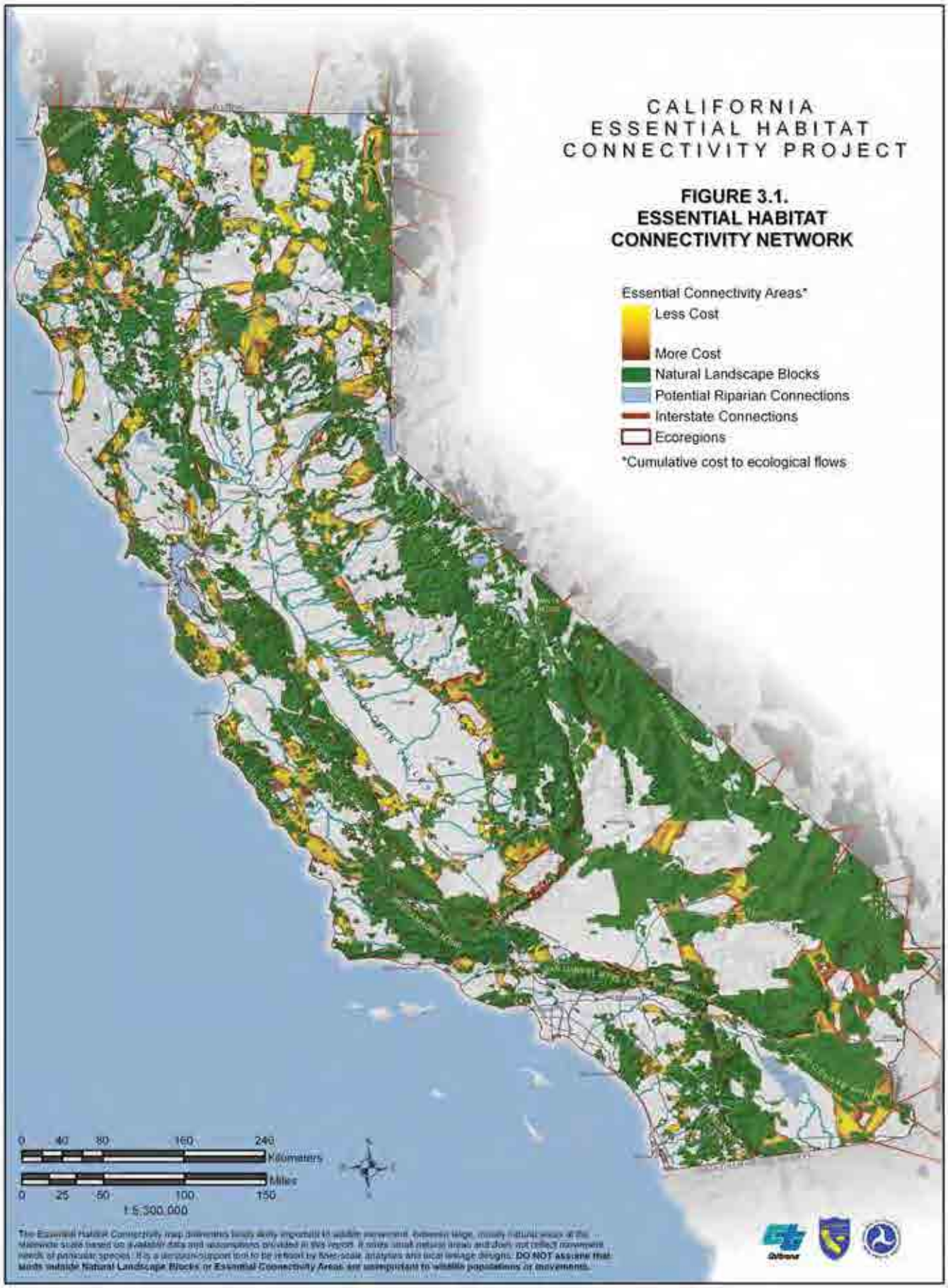

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.1.
ESSENTIAL HABITAT
CONNECTIVITY NETWORK
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregions
*Cumulative cost to ecological flows
0 40 80 160 240
Kilometers
Miles
0 25 50 100 150
1:5,300,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement, between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by fine-scale analysis and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Table 3.1. Mean, minimum, and maximum for metrics in 850 Natural Landscape Blocks (NLBs) and 192 Essential Connectivity Areas (ECAs). See Table 2.4 for data sources and definitions.

	Descriptor	Mean (Min-Max) for 850 Natural Landscape Blocks	Mean (Min-Max) for 192 Landscape Essential Connectivity Areas
Landform	Elevation (m)	664 (-65 to 2,570; 589 SD)	661 (-1 to 2,006, 565 SD)
	Elevation range (difference between maximum and minimum)	614 (1 to 4,100; 598 SD)	967 (6 to 3,440; 716 SD)
	Mean Ecological Condition Index	75 (0 to 100; 25 SD)	53 (3 to 100; 22 SD)
Area	Area in acres	51,000 (2,000 to 3,676,000; 181,000 SD)	97,500 (1,400 to 1,461,000; 160,000 SD)
Essential Connectivity Area	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	15 (0.1 to 75; 16 SD)
	Length of least-cost path within ECA (km)	Not applicable	21 (0.1 to 130; 21 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	60 (0 to 100; 40 SD)	39 (0 to 100; 33 SD)
	Percent GAP1, GAP2, or easements	44 (0 to 100; 41 SD)	13 (0 to 92; 18 SD)
	Percent GAP3	16 (0 to 100; 40 SD)	26 (0 to 100; 29 SD)
	Percent in private, unprotected status	40 (0 to 100; 40 SD)	61 (0 to 100; 33 SD)
Species diversity	Mean number of amphibians, reptiles, mammals, and birds whose modeled habitat overlaps each CWHR hexagon	237 (128 to 320; 33 SD)	233 (142 to 280; 30 SD)
	Standard deviation of number of species per CWHR hexagon	7	9
	Number of CNDDB special status plant taxa	6 (0 to 162; 11 SD)	13 (0 to 72; 14 SD)
	Number of CNDDB special status animal taxa	6 (0 to 85; 7 SD)	13 (0 to 53; 10 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	11 (0 to 100; 29 SD)	7 (0 to 100; 20 SD)
Habitat for listed species	Percent in USFWS-designated Critical Habitat	16 (0 to 100; 29 SD)	12 (0 to 100; 19 SD)
	Number of species with Critical Habitat	0.8 (0 to 11;1.4 SD)	1.6 (0 to 11; 2.1 SD)
	Percent in USFWS-mapped essential habitat	23 (0 to 100; 37 SD)	13 (0 to 100; 23 SD)
	Number of species with essential habitat	0.6 (0 to 9; 0.9 SD)	0.9 (0 to 9;1.3 SD)

Wet-lands	Percent in wetland or vernal pool	9 (0 to 100; 22 SD)	6 (0 to 76; 13 SD)
Paved roads	Number of intersections by major roads	Not applicable	1 (0 to 6; 1 SD)
	Density of major roads (km/km^2)	0 (0 to 0)	0.1 (0 to -1.2; 0.1 SD)
	Density of secondary state and county highways (km/km^2)	0 (0 to 0)	0.2 (0 to 2.8; 0.2 SD)
Eco-regions	Number of Jepson ecoregions	1.2 (1 to 4;0.4 SD)	1 (1 to 4; 0.6 SD)
	Number of ecoregion subsections	2.1 (1 to 14; 1.3 SD)	3 (1 to 11; 1.8 SD)
	Number of watersheds	2.7 (1 to 12; 1.7 SD)	1.8 (1 to 10; 1.1 SD)
ACEC	Percent in BLM Areas of Critical Environmental Concern based on the area's biological values	6 (0 to 100; 21 SD)	2 (0 to 84; 7 SD)
	Number of counties	1.3 (1 to 8; 0.7 SD)	2 (1 to 4; 0.9 SD)
Landcover	Percent forest and woodland	24 (0 to 97; 32 SD)	29 (0 to 93; 34 SD)
	Percent shrubland, steppe, or savanna	38 (0 to 100; 32 SD)	28 (0 to 96;27 SD)
	Percent herbaceous	20 (0 to 99;30 SD)	17 (0 to 98; 23 SD)
	Percent wetland/riparian	5 (0 to 82; 10 SD)	4 (0 to 63; 8 SD)
	Percent open water	1 (0 to 65; 5 SD)	1 (0 to 20;2 SD)
	Percent developed	2 (0 to 32; 3 SD)	5 (0 to 25; 5 SD)
	Percent cultivated crops	3 (0 to 93; 11 SD)	7 (0 to 69; 15 SD)
	Percent hay/pasture	2 (0 to 81; 8 SD)	3 (0 to 45; 8 SD)
	Percent barren or other	5 (0 to 99; 13 SD)	5 (0 to 98; 12 SD)

Major rivers are also shown on the Essential Habitat Connectivity Map to represent where aquatic and riparian corridors may further contribute to ecological connectivity. Riparian areas, although generally narrower than Essential Connectivity Areas, are very important to maintaining ecological connectivity throughout much of the state. Many long riparian corridors connect Natural Landscape Blocks and Essential Connectivity Areas through otherwise inhospitable matrix lands (e.g., urban and agricultural areas), while also maintaining aquatic habitats and flows for numerous species and important ecological processes. In many places, like the Great Central Valley, riparian corridors may be the primary avenues for wildlife movement and other ecological flows between remaining habitat areas. Although aquatic connectivity and riparian restoration are not a focus of this report, maintaining and enhancing riparian corridors and aquatic systems will also greatly enhance overall ecological connectivity throughout the state, and should be a focus of regional and local connectivity plans (Chapters 4 – 6).

Although most Natural Landscape Blocks and Essential Connectivity Areas comprise relatively natural landcovers with high ecological integrity, they vary greatly in their

ecological condition, biological values, resistance to ecological flows, and degree of conservation protection. Compared to Essential Connectivity Areas, Natural Landscape Blocks tend to score higher in Ecological Condition Index, have more protected land, and contain less agriculture and development. These differences reflect the stringent, ecoregion-specific rules used to define Natural Landscape Blocks, which delineated Natural Landscape Blocks as the largest, most natural, and best-conserved portions of each ecoregion. Essential Connectivity Areas tend to include more developed and agricultural landcovers (Table 3.1) than Natural Landscape Blocks.

In all ecoregions, Essential Connectivity Areas generally connect areas of both High Biological Value and high conservation status across mostly natural habitats that have relatively low resistance to ecological flows, but that tend not to enjoy high levels of protection of biological resource values. For instance, many Essential Connectivity Areas in forested ecoregions comprise National Forest or private timber lands lying between large National Parks, wilderness areas, or other highly protected lands. These multiple-use areas may be managed primarily for timber harvest, recreation, or other land uses, but may nevertheless support diverse and valuable biological resources and be highly permeable to ecological flows. Inclusion of such lands within Essential Connectivity Areas highlights opportunities to manage them in ways that promote functional ecological connectivity between the highly protected parks, wildlife reserves, and wilderness areas.

Similarly, large areas of natural desert habitats on multiple-use BLM lands and military training lands were excluded from Natural Landscape Blocks, because they didn't meet the stringent criteria of being both highly conserved (GAP1 or 2 lands) AND being mapped as having High Biological Value. Nevertheless, extensive desert areas outside of Natural Landscape Blocks do support valuable biological resources and tend to be highly permeable to ecological flows. Including some such lands in Essential Connectivity Areas highlights the need to maintain functional ecological connectivity between existing protected areas across the desert landscape. Lands within Essential Connectivity Areas should be targets for additional conservation protection and management to ensure that wildlife movements, ecological range shifts, and other ecological flows are maintained in the future. However, it is important to recognize that even areas outside of Natural Landscape Blocks and Essential Connectivity Areas support important ecological values that should not be treated as lacking conservation value. In relatively intact, "low-contrast" landscapes, such as California's deserts, managing the entire landscape to sustain ecological permeability is a worthy conservation goal.

In contrast to the relatively intact mountain and desert ecoregions, many landcovers in Essential Connectivity Areas in other regions are of lower ecological condition and less permeable to ecological flows, such as the extensive agricultural areas of the Great Central Valley and urban and suburban development in the Bay Area, Central Coast, and South Coast Ecoregions. In these relatively "high-contrast" landscapes, maintaining or enhancing permeability to wildlife movement and ecological flows may be quite challenging, and will likely require greater focus on ecological restoration to sustain or enhance habitat values and permeability. Maintaining and enhancing riparian corridors in such regions should be a high conservation priority, as these corridors often represent the only remaining, relatively natural

connections between remnant habitat areas, in addition to having intrinsic habitat value for diverse species.

Limitations of the Maps—Although objective, repeatable rules are necessary for a transparent science-based product, no single set of rules can produce a perfect map of Natural Landscape Blocks and Essential Connectivity Areas for California, given the state's extreme biogeographic diversity and the limited number and quality of available statewide data layers. The map probably does not depict any Natural Landscape Block or Essential Connectivity Area that should not have been recognized, but may depict a few non-functional Essential Connectivity Areas[22]. In addition, the map probably excludes a few areas that should have been recognized. Such omissions should be addressed by future regional and local analyses (see Chapters 4-6). For example, large expanses of the western slope of the Sierra Nevada contain no Natural Landscape Blocks or Essential Connectivity Areas, such that the map shows a lack of north-south connectivity through the region, primarily on National Forests downslope of the high-elevation National Parks and Wilderness Areas. These large expanses of forests, woodlands, and chaparral nevertheless support diverse and important biological resources, and there is a need for north-south connectivity along the western slope of the Sierra Nevada to accommodate connectivity for such species as the fisher (*Martes pennanti*) and California spotted owl (*Strix occidentalis occidentalis*).

A second example of potential errors of omission in the Essential Habitat Connectivity Map is the lack of east-west Essential Connectivity Areas across the Great Central Valley, or connecting foothill habitats on either side to Natural Landscape Blocks on the Valley floor. This is due to low average Ecological Condition Index values and the paucity of protected areas in the Valley, coupled with the stringent rules for determining which Natural Landscape Blocks to connect (Section 2.2). However, connectivity of remaining habitat areas in the Great Central Valley is of considerable conservation concern. Regional and local connectivity plans for the Valley need to address these omissions with a focus on ecological restoration and enhancement (see, for example, Huber 2008 and Huber et al. 2010).

One final example of apparent "errors of omission" concerns large portions of the Mojave Desert Ecoregion that were excluded from the Essential Connectivity Network because they are on military bases. The stringent rules used in the deserts to delineate Natural Landscape Blocks excluded Department of Defense lands as not having GAP 1 or 2 protection status, despite that large portions of these bases are actually well protected from human influences and are quite pristine, ecologically intact, and have high biological resource values. Ongoing regional and local planning is addressing connectivity needs in the deserts, with Department of Defense as an active partner. Results of those finer-scale analyses should be used to improve the Essential Habitat Connectivity Map (see Section 3.3.10).

[22] Several Essential Connectivity Areas in highly developed areas may not currently support animal movement and ecological processes, and a few of these may not be fully, or even partially, restorable. We mapped these as Essential Connectivity Areas to avoid portraying some Natural Landscape Blocks as "hopelessly isolated" before more detailed analyses have been conducted to justify such a conclusion.

3.2. Ecoregional Summaries

The following sections provide more detailed ecoregion-by-ecoregion overviews (working from north to south) of the Essential Connectivity Map, with general descriptions of the Natural Landscape Blocks, Essential Connectivity Areas, and surrounding matrix lands. These are intended primarily to highlight limitations to the maps and provide guidance for future analyses and connectivity plans, as described in Chapters 4 through 7.

3.2.1. North Coast

The North Coast Ecoregion is characterized by large expanses of rugged, forested mountains. It is California's wettest ecoregion, especially coastward of the major mountain ranges (Klamath, Siskiyou, Marble, Trinity, and North Coast). Consequently, the ecoregion is crossed by numerous large rivers and is capable of supporting large, fast-growing trees, such as California's massive coastal redwoods. Forestry is the most widespread land use in the region, and historical forest management practices have severely altered and fragmented its natural communities, resulting in generally younger, more even-aged, less structurally diverse forests. The few remaining late-seral forests are scattered in relative isolation of one another.

The North Coast Ecoregion contains 96 Natural Landscape Blocks from 2,000 to 732,500 acres each, which are interconnected by 24 Essential Connectivity Areas that are wholly within the ecoregion (totaling about 78,300 acres) (Figure 3.2, Table 3.2). In addition to these, there are 22 Natural Landscape Blocks and 16 Essential Connectivity Areas that are shared between the North Coast and other ecoregions. Most Natural Landscape Blocks in the North Coast Ecoregion are associated with parks (e.g., Redwood National Park) and wilderness areas (e.g., Marble Mountains Wilderness) in heavily forested mountains and rugged coastal regions. They are mostly forested (63%) and average relatively high on the Ecological Condition Index (82). The Essential Connectivity Areas are also primarily in forest landcovers (74%). They are mostly on privately owned lands (56%), which have traditionally been managed for timber harvest, and National Forests (about 40%), which are managed for multiple uses (e.g., wood, water, livestock forage, wildlife, and recreation), with an historic focus on timber harvest. As a result these forests have been significantly altered and fragmented, and average a moderate Ecological Condition Index of 64. Many of the Essential Connectivity Areas are quite long (up to about 70 km), but these generally span multiple smaller "stepping-stone" blocks between the larger Natural Landscape Blocks they serve to connect. Numerous roads cross the Essential Connectivity Areas (with an average of over 50 km of major and secondary roads in each), but many of these are small and lightly traveled rural roads. Extremely rugged terrain in the ecoregion constrains most highways to following major river canyons over much of their length. The ecoregion also has five placeholder "sticks" to reserve areas in neighboring Oregon, indicating where future connectivity planning, in collaboration with agencies in Oregon, is recommended.

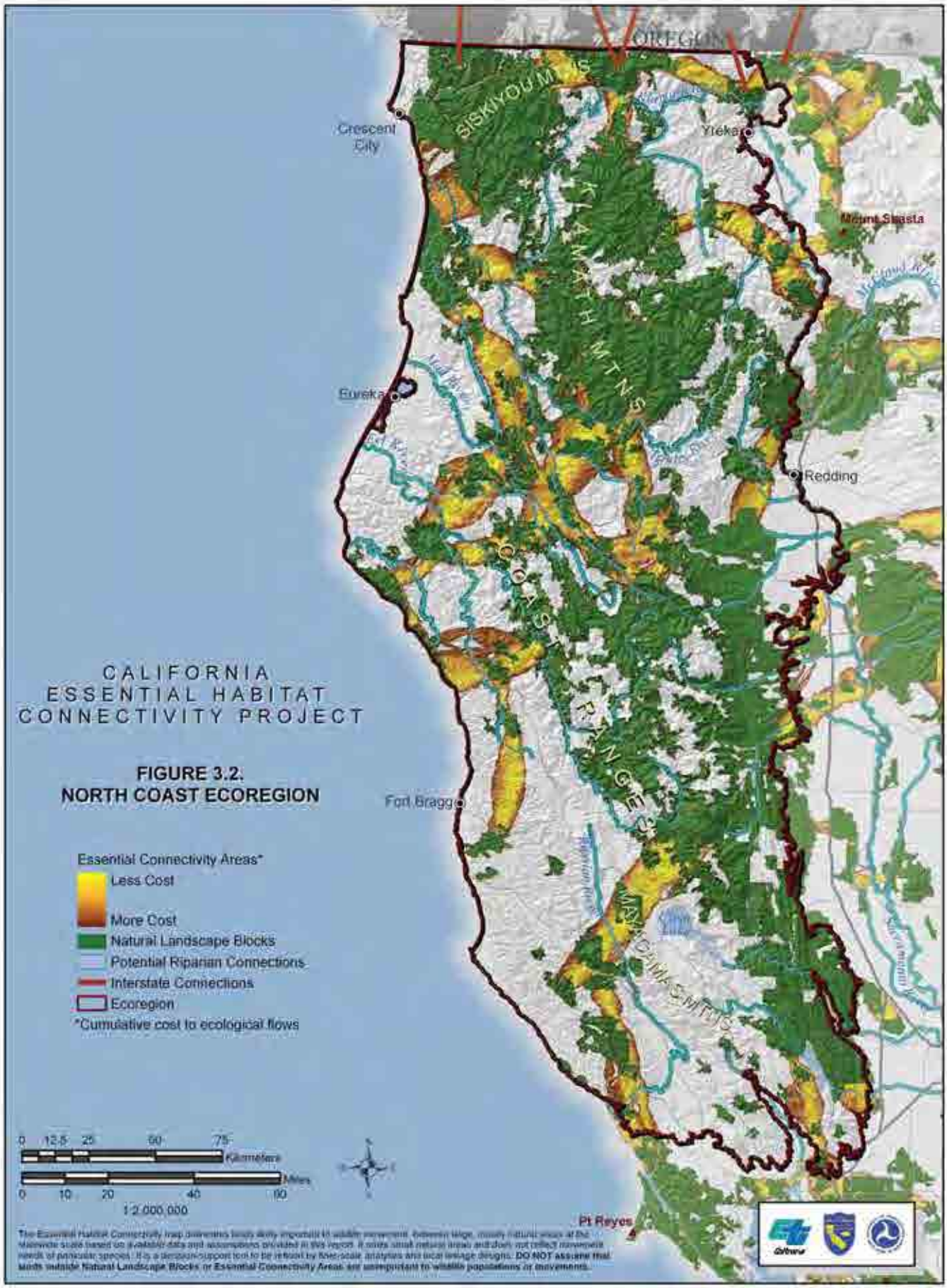

OREGON
SISKIYOU MTNS
Crescent City
Yreka
Mount Shasta
KLAMATH MTNS
Eureka
Redding
COAST RANGES
CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.2.
NORTH COAST ECOREGION
Fort Bragg
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
*Cumulative cost to ecological flows
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:2,000,000
Pt Reyes

Table 3.2. Mean and standard deviation for metrics in 96 Natural Landscape Blocks and 24 Essential Connectivity Areas wholly within the North Coast Ecoregion. See Table 2.4 for data sources and definitions.

	Descriptor	Mean for 96 Natural Landscape Blocks	Mean for 24 Essential Connectivity Areas
Landform	Elevation (m)	669 (8 to 2,196; 404 SD)	761 (330 to 1,360; 344 SD)
	Elevation range	897 (25 to 2,630; 497 SD)	1,377 (732 to 1,872; 373 SD)
	Mean Ecological Condition Index	82 (0 to 97; 16 SD)	64 (50 to 72; 5 SD)
	Area in acres	41,700 (2,000 to 732,500; 100,800 SD)	87,400 (6,100 to 326,500; 78,300 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	14 (0.1 to 45; 15 SD)
	Length of least cost path within ECA (km)	Not applicable	17 (0.1 to 59; 18 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	66 (0 to 100; 37 SD)	44 (0 to 96; 30 SD)
	Percent GAP1, GAP2, or easements	48 (0 to 100; 41 SD)	8 (0 to 31; 9 SD)
	Percent in private, unprotected status	34 (0 to 100; 37 SD)	56 (4 to 100; 30 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	4 (0 to 100; 18 SD)	1 (0 to 29; 6 SD)
Listed species	Percent in USFWS-designated Critical Habitat	21 (0 to 98; 29 SD)	20 (0 to 63; 18 SD)
	Percent in USFWS-mapped essential habitat	4 (0 to 99; 15 SD)	0 (0 to 12; 2 SD)
	Percent in wetland or vernal pool	1 (0 to 28; 3 SD)	0 (0 to 2; 1 SD)
Land Cover	Percent forest and woodland	63 (0 to 97; 30 SD)	74 (19 to 93; 22 SD)
	Percent shrubland, steppe, or savanna	24 (0 to 88; 24 SD)	14 (1 to 57; 16 SD)
	Percent herbaceous	6 (0 to 75; 10 SD)	4 (0 to 18; 6 SD)
	Percent wetland/riparian	1 (0 to 5; 1 SD)	0 (0 to 2; 1 SD)
	Percent open water	1 (0 to 59; 6 SD)	0 (0 to 1; 0 SD)
	Percent developed	1 (0 to 7; 1 SD)	4 (1 to 9; 2 SD)
	Percent cultivated crops	0 (0 to 5; 1 SD)	0 (0 to 3; 1 SD)
	Percent hay/pasture	0 (0 to 5; 1 SD)	0 (0 to 0; 0 SD)
	Percent barren or other	3 (0 to 38; 6 SD)	4 (0 to 10; 3 SD)

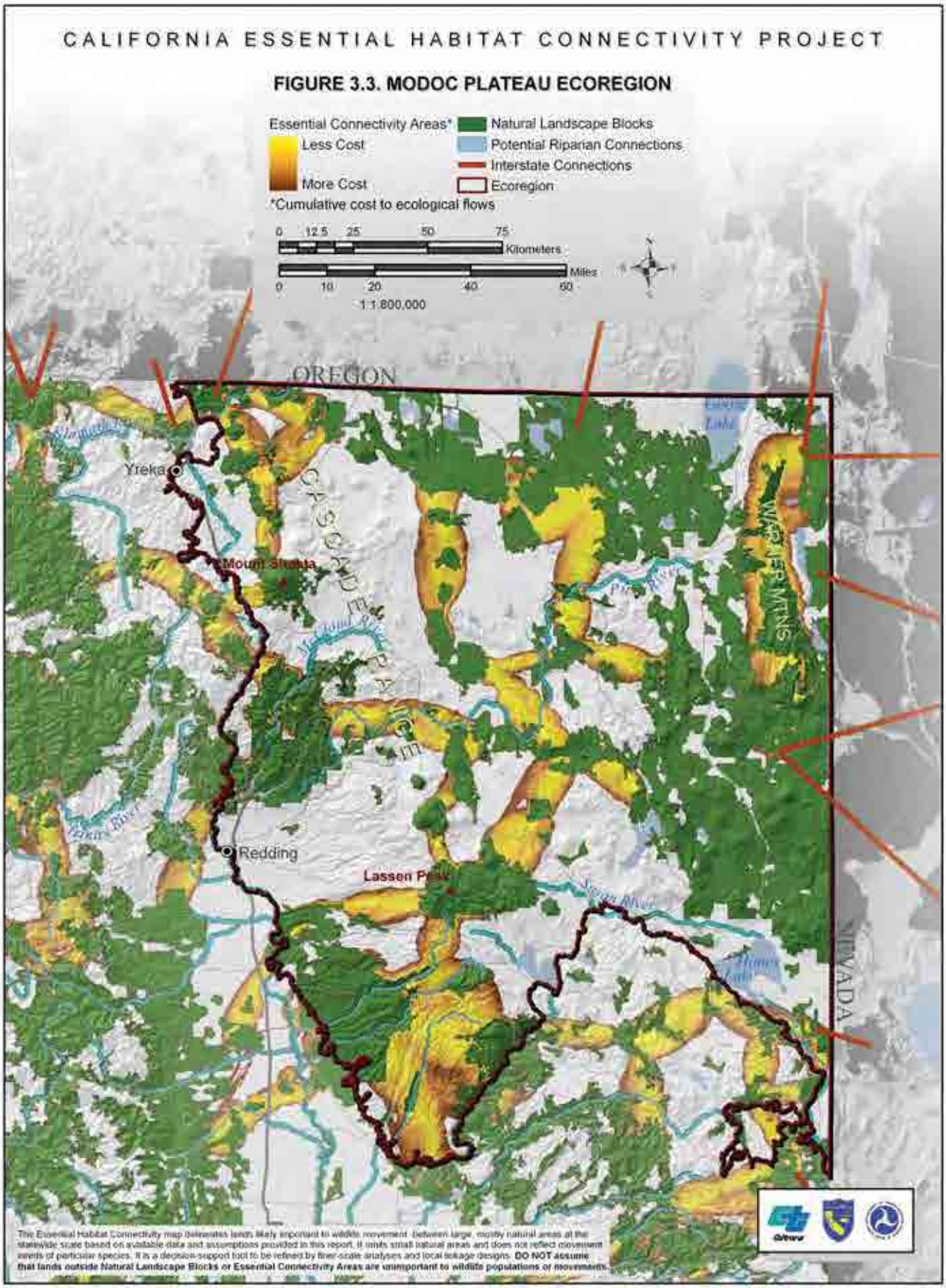
A major focus of regional and local connectivity planning in the North Coast Ecoregion should be to sustain and enhance connectivity of high-integrity forest habitats within Natural Landscape Blocks and Essential Connectivity Areas. Essential Connectivity Areas should be

assessed for opportunities to increase the size and continuity of dense, late-seral forests for the diverse focal species that depend on them, such as the rare Humboldt marten (*Martes americana humboldtensis*), fisher (*Martes pennanti*), northern spotted owl (*Strix occidentalis*), and marbled murrelet (*Brachyramphus marmoratus*). Increasing the amount of late-seral coniferous forests in this rainy and highly productive forest region would also increase carbon sequestration to help mitigate against global climate change. Consult the California Wildlife Action Plan (Bunn et al. 2007) for a more thorough description of the ecoregion's resources, threats, and conservation priorities.

3.2.2. Modoc Plateau

The Modoc Plateau Ecoregion comprises the northeastern portion of the state, stretching from the North Coast Ecoregion east to the Nevada border, and includes the Cascade Mountain Range as well as the Modoc Plateau proper. The region is topographically and climatically diverse, with numerous volcanic peaks (e.g., Mount Shasta and Mount Lassen), broad lava-formed plateaus, and steep river canyons. The Modoc Plateau lies east of the Cascades, on the western edge of the Great Basin, and supports high-desert ecosystems, including shrub-steppe, perennial grasslands, and juniper woodlands. Conifer forests dominate the higher mountains, such as the Cascade and Warner Ranges. Diverse aquatic ecosystems, including large freshwater and saline lakes, important trout streams, and several managed wetland refuges, are found throughout the region. Although there are a number of large parks and wilderness areas in the Cascades (e.g., Lassen Volcanic National Park, Lava Beds National Monument, Mount Shasta Wilderness, Ishi Wilderness) and several large wildlife refuges in the region (e.g., Lower Klamath, Tule Lake, and Clear Lake National Wildlife Refuges and Tehama and Ashe Creek State Wildlife Areas), the Modoc Plateau region is among the lowest in the state in the proportion conserved for biological resources. Most of the region is managed for multiple uses by the US Forest Service and Bureau of Land Management, with about a third of the area in private ownership. Natural communities on both federal and private lands have been widely degraded by overgrazing (by livestock as well as feral horses), invasive annual grasses, altered fire regimes, timber management, and other stressors (Bunn et al. 2007).

The Modoc Plateau Ecoregion has 124 Natural Landscape Blocks (100 totally within the region and 24 extending into other regions) ranging from 2,000 to 790,000 acres each. They are interconnected by 19 Essential Connectivity Areas wholly within the ecoregion (Figure 3.3, Table 3.3) plus about 17 connecting into other ecoregions. Most Natural Landscape Blocks are associated with the various national parks and wilderness areas (especially at higher elevations) or wildlife refuges (especially at lower elevations) and have generally very high ecological integrity (ECI scores average 88). The Essential Connectivity Areas lie primarily on National Forest, Bureau of Land Management, and privately owned lands, with only 9% protected as Gap 1 or 2 conservation lands and a modest average Ecological Condition Index of 60. The Essential Connectivity Areas average nearly 24 km long, but there are numerous smaller stepping-stone blocks along the longer ones. Major landcovers within Essential Connectivity Areas are forests and woodlands (66%) and shrublands (22%). Numerous roads cross the Essential Connectivity Areas (averaging about 47 km of road in each), but many of these are small and lightly traveled rural roads.


CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT
FIGURE 3.3. MODOC PLATEAU ECOREGION
Essential Connectivity Areas*
Less Cost
More Cost
*Cumulative cost to ecological flows
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:1,800,000
OREGON
Yreka
Mount Shasta
CASCADE RANGE
Redding
Lassen Peak
WARNER MTNS
NEVADA
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

The ecoregion also has eight placeholder "sticks" to reserve areas in Oregon and Nevada, indicating where future connectivity planning, in collaboration with agencies in these states, is recommended.

Table 3.3. Mean and standard deviation for metrics in 100 Natural Landscape Blocks and 19 Essential Connectivity Areas wholly within the Modoc Plateau Ecoregion. See Table 2.4 for data sources and definitions.

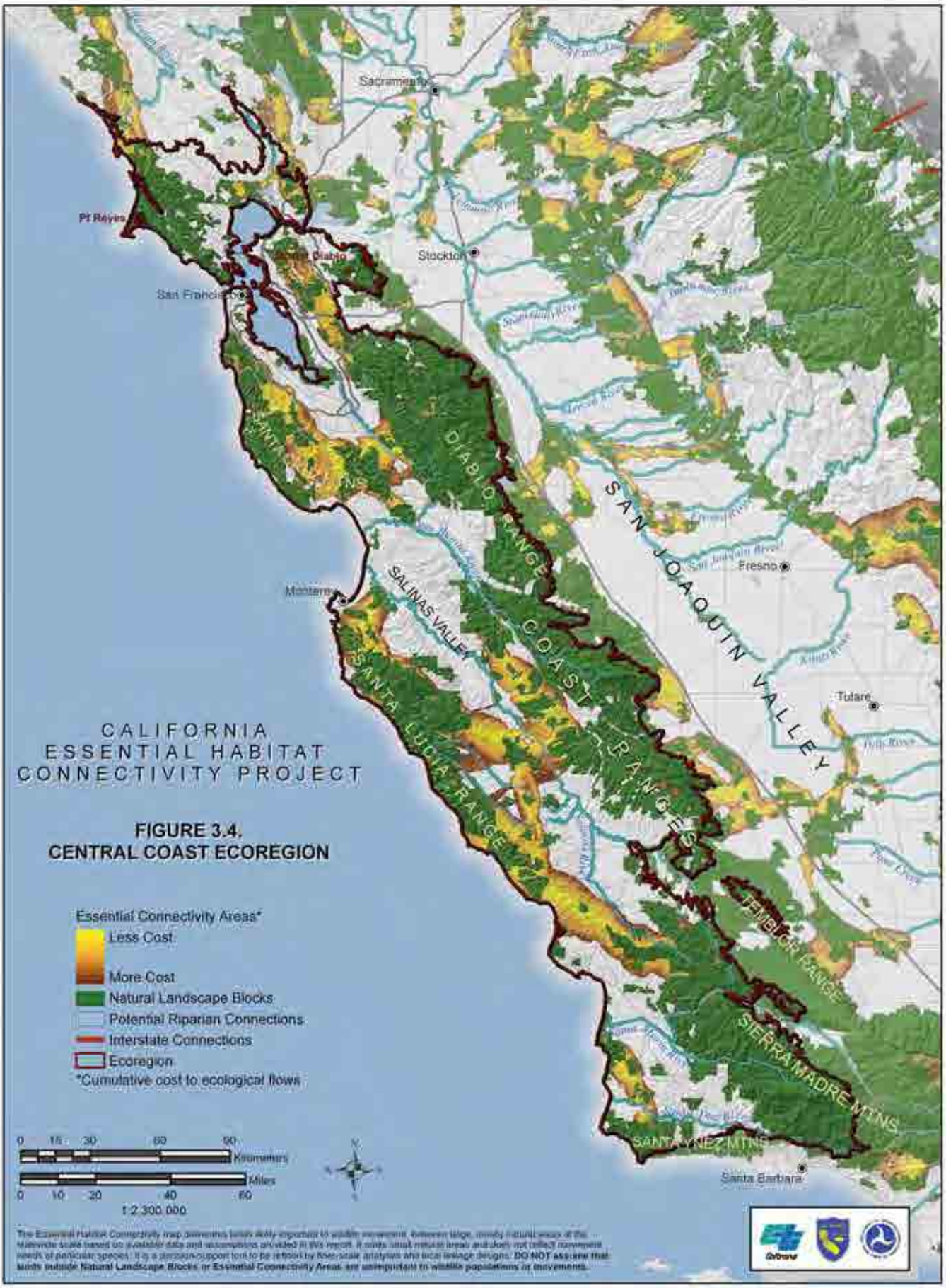
	Descriptor	Mean for 100 Natural Landscape Blocks	Mean for 19 Essential Connectivity Areas
Landform	Elevation (m)	1,330 (276 to 2,189; 405 SD)	1,484 (998 to 1,934; 269 SD)
	Elevation range	539 (5 to 3,247; 487 SD)	1,200 (336 to 2,874; 643 SD)
	Mean Ecological Condition Index	88 (1 to 99; 17 SD)	60 (50 to 76; 7 SD)
	Area in acres	34,800 (2,000 to 790,000; 88,000 SD)	100,200 (15,000 to 300,100; 70,700 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	17 (1 to 49; 14 SD)
	Length of least cost path within ECA (km)	Not applicable	24 (2 to 51; 15 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	67 (0 to 100; 34 SD)	61 (21 to 100; 27 SD)
	Percent GAP1, GAP2, or easements	29 (0 to 100; 38 SD)	9 (0 to 48; 13 SD)
	Percent in private, unprotected status	33 (0 to 100; 34 SD)	39 (0 to 79; 27 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	0 (0 to 15; 2 SD)	0 (0 to 0; 0 SD)
Listed species	Percent in USFWS-designated Critical Habitat	4 (0 to 100; 16 SD)	4 (0 to 39; 10 SD)
	Percent in USFWS-mapped essential habitat	5 (0 to 100; 17 SD)	2 (0 to 8; 3 SD)
	Percent in wetland or vernal pool	8 (0 to 99; 18 SD)	3 (0 to 8; 2 SD)
Land Cover	Percent forest and woodland	39 (0 to 96; 33 SD)	66 (24 to 86; 18 SD)
	Percent shrubland, steppe, or savanna	39 (0 to 98; 32 SD)	22 (2 to 72; 18 SD)
	Percent herbaceous	2 (0 to 40; 5 SD)	1 (0 to 6; 2 SD)
	Percent wetland/riparian	5 (0 to 36; 6 SD)	3 (0 to 7; 2 SD)
	Percent open water	2 (0 to 63; 7 SD)	0 (0 to 1; 0 SD)
	Percent developed	0 (0 to 4; 1 SD)	1 (0 to 2; 1 SD)
	Percent cultivated crops	3 (0 to 65; 10 SD)	2 (0 to 8; 3 SD)
	Percent hay/pasture	5 (0 to 68; 13 SD)	1 (0 to 5; 2 SD)
	Percent barren or other	6 (0 to 84; 14 SD)	3 (0 to 10; 3 SD)

A major focus of regional and local connectivity planning in the Modoc Plateau Ecoregion should be working to sustain and enhance connectivity of high-integrity forest habitats in the mountains, and restoring ecological integrity to degraded Great Basin communities (e.g., shrub steppe and perennial grass communities). Essential Connectivity Areas should be assessed for opportunities to increase the size and continuity of higher canopy closure, late-seral forests for such species as pine marten and northern goshawk (*Accipiter gentilis*) as well as shrub-steppe and perennial grassland habitats that support such species as greater sage grouse (*Centrocercus urophasianus*) and pronghorn (*Antilocapra americana*). Consult the California Wildlife Action Plan (Bunn et al. 2007) for a more thorough description of the ecoregion's resources, threats, and conservation priorities.

3.2.3. Central Coast

The Central Coast Ecoregion includes coastal mountains, valleys, and plains along the Pacific Ocean from about the Russian River and Sonoma Valley on the north to Point Conception on the south. The region is characterized by a rugged coastline and many mountain ranges roughly paralleling the Pacific coast and the hills surrounding San Francisco Bay. The mountain ranges are separated by fertile, alluvial river valleys near the coast, with more arid valleys and hills further inland. The region's topographic, climatic, and edaphic complexities result in diverse coastal, montane, and desert-like ecological communities—ranging from coastal wetlands and maritime chaparral, to redwood forests, to arid grasslands and shrublands. Large portions of the region are highly urbanized, especially in the San Francisco Bay Area and near Monterey and San Luis Obispo Bays. The broad, fertile river valleys, such as Salinas Valley, as well as some broad coastal terraces, have been largely converted to agriculture. Most remaining natural vegetation is therefore restricted to the more rugged coastal mountains and arid inland valleys and hills. In addition to expanding agricultural areas and urban and exurban development, excessive livestock grazing is a major stressor on the region's natural communities (Bunn et al. 2007). Numerous large and heavily traveled highways also fragment and isolate natural areas from one another and impede wildlife movements.

The highly fragmented Central Coast Ecoregion has 129 total Natural Landscape Blocks (including 103 totally within the region and 26 shared with neighboring regions) which are served by 24 Essential Connectivity Areas (12 wholly within the ecoregion and 12 shared with adjacent regions) (Figure 3.4 and Table 3.4). The Natural Landscape blocks are mostly in rugged areas, with generally smaller, more fragmented blocks on the region's gentler slopes, terraces, and valleys due to the widespread conversion to urban and agricultural land uses. Landcover composition of the Natural Landscape Blocks is diverse, reflecting this ecoregion's tremendous ecological diversity, with various shrubland (44%), grassland/herbaceous (25%), forest/woodland (19%), and wetland/riparian (4%) types well represented. The average Ecological Integrity Condition is moderate but highly variable among blocks (61 $\pm$ 30 SD). The Essential Connectivity Areas are likewise diverse in landcover composition. Because they tend to connect the more rugged areas across the region's valleys and plains, the Essential Connectivity Areas have a higher proportion of landcover in urban (11%) and agriculture (6%) than the Natural Landscape Blocks, and they have a relatively low average Ecological Condition Index (44). They also are crossed by


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.4.
CENTRAL COAST ECOREGION
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
*Cumulative cost to ecological flows
0 15 30 60 90
Kilometers
Miles
0 10 20 40 60
1:2,300,000
Sacramento
Pt Reyes
Mt. Diablo
Stockton
San Francisco
Monterey
Fresno
Tulare
Santa Barbara
DIABLO RANGE
SALINAS VALLEY
COAST RANGES
SANTA LUCIA RANGE
SAN JOAQUIN VALLEY
TEHACHAPI RANGE
SIERRA MADRE MTNS
SANTA YNEZ MTNS

numerous major and secondary roads, with an average of 149 km of roads per Essential Connectivity Area.

Table 3.4. Mean and standard deviation for metrics in 103 Natural Landscape Blocks and 12 Essential Connectivity Areas wholly within the Central Coast Ecoregion. See Table 2.4 for data sources and definitions.

	Descriptor	Mean for 103 Natural Landscape Blocks	Mean for 12 Essential Connectivity Areas
Landform	Elevation (m)	266 (1 to 816; 170 SD)	303 (108 to 407; 104 SD)
	Elevation range	431 (3 to 1,782; 258 SD)	871 (412 to 1,524; 356 SD)
	Mean Ecological Condition Index	61 (0 to 98; 30 SD)	44 (9 to 75; 22 SD)
	Area in acres	15,900 (2,000 to 475,000; 48,200 SD)	123,000 (6,300 to 345,700; 101,300 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	23 (2 to 61; 19 SD)
	Length of least cost path within ECA (km)	Not applicable	28 (5 to 74; 21 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	59 (0 to 100; 37 SD)	23 (1 to 47; 14 SD)
	Percent GAP1, GAP2, or easements	53 (0 to 100; 38 SD)	15 (0 to 33; 10 SD)
	Percent in private, unprotected status	41 (0 to 100; 37 SD)	77 (53 to 99; 14 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	33 (0 to 100; 44 SD)	7 (0 to 45; 15 SD)
Listed species	Percent in USFWS-designated Critical Habitat	17 (0 to 100; 28 SD)	12 (0 to 35; 12 SD)
	Percent in USFWS-mapped essential habitat	48 (0 to 100; 44 SD)	30 (0 to 85; 27 SD)
	Percent in wetland or vernal pool	4 (0 to 62; 10 SD)	0 (0 to 3; 1 SD)
Land Cover	Percent forest and woodland	19 (0 to 92; 23 SD)	22 (1 to 68; 20 SD)
	Percent shrubland, steppe, or savanna	44 (0 to 93; 25 SD)	44 (19 to 71; 17 SD)
	Percent herbaceous	25 (0 to 93; 27 SD)	15 (1 to 44; 13 SD)
	Percent wetland/riparian	4 (0 to 71; 11 SD)	2 (0 to 4; 1 SD)
	Percent open water	2 (0 to 65; 9 SD)	1 (0 to 5; 1 SD)
	Percent developed	4 (0 to 19; 4 SD)	11 (5 to 23; 7 SD)
	Percent cultivated crops	1 (0 to 61; 6 SD)	5 (0 to 34; 10 SD)
	Percent hay/pasture	0 (0 to 3; 0 SD)	1 (0 to 2; 1 SD)
	Percent barren or other	1 (0 to 45; 5 SD)	0 (0 to 1; 0 SD)

Major foci of regional and local connectivity planning in the Central Coast Ecoregion must be maintaining and enhancing functional connectivity across numerous roads, agricultural areas, and urbanizing areas. This challenge is already being tackled by existing connectivity planners in portions of the region. For example, Thorne et al. (2002) used a focal species approach to develop a guide to wildlands conservation in the Central Coast region. T. Diamond (2010) has analyzed movement of badgers and other species in the Essential Connectivity Area connecting the Diablo Range to the Santa Cruz Mountains across Coyote Valley, and there is an ongoing effort by university scientists and Caltrans to assess and enhance wildlife connectivity across Highway 101 in the Essential Connectivity Area between the Sierra Madre and Santa Lucia Range (P. Huber, personal communication). Developing Natural Community Conservation Plans in this ecoregion are also addressing connectivity conservation in this ecoregion—including the Santa Clara Valley Conservation Plan, which has been in development for several years, and a recently initiated North San Luis Obispo County Conservation Program. Finally, a recently initiated regional effort intends to develop local Linkage Designs around the San Francisco Bay area (see Section 3.3.12).

Other documented connectivity issues in the region include (1) maintaining potential for Endangered San Joaquin kit fox (*Vulpes macrotis mutica)* movement corridors from Camp Roberts Military Reservation in the central part of this ecoregion southeast into the Carrizo Plain and the San Joaquin Valley and northeast toward the Cholame Hills area, and (2) preserving a corridor along the Pajaro River and adjacent lands from the Santa Cruz Mountains to the Diablo Range and Santa Lucia Mountains for wide-ranging species (Bunn et al. 2007).

3.2.4. Great Central Valley

The Great Central Valley Ecoregion comprises the Sacramento Valley in the north, the San Joaquin Valley in the south, and the Sacramento-San Joaquin Delta in between, where the waters from California's two great central watersheds come together before flowing to the Pacific—or, via pipes and canals, to agricultural and urban areas throughout much of the state. This ecoregion comprises most of the low-lying lands of Central California, bounded between the Coast Ranges on the west, Sierra Nevada and Cascade Ranges on the east, and the Tehachapi Range on the south. The Sutter Buttes, a circular set of volcanic hills, rises about 2,000 feet from the floor of the Sacramento Valley. The vast majority of the valley is in private ownership, but there are a large number of wildlife refuges and other preserves scattered throughout, including many important wetland refuges and grassland reserves.

The Great Central Valley is largely converted to agricultural and urban landcovers, with remaining natural communities severely reduced. For example, 99.9% of the region's historic native grasslands, 99% of valley oak savannah, 95% of wetlands, and 89% of riparian woodlands have been converted (Bunn et al. 2007). Nevertheless, the Valley still supports diverse native and endemic species and has numerous important wildlife reserves, especially in wetland areas along the many waterways. There are also some important grassland and shrubland areas, especially around the margins of the Valley and adjacent foothills, which support a variety of rare and Endangered species, such as the San Joaquin kit fox, blunt-nosed leopard lizard (*Gambelia sila*), and several endemic kangaroo rats

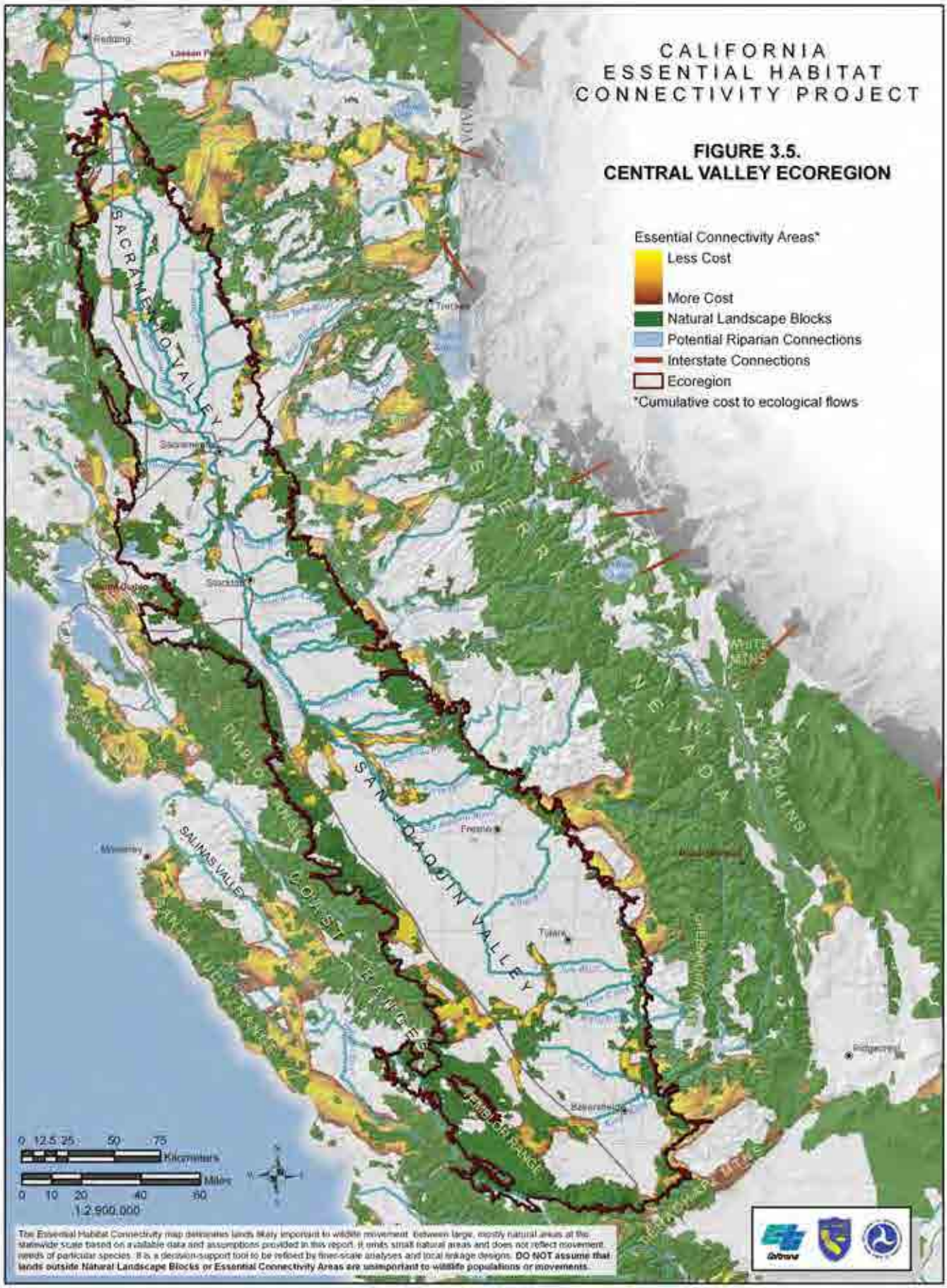
(*Dipodomys* spp.). There are also numerous vernal pools on remaining grasslands in the region, including large vernal pool complexes that are an important source of regional biodiversity and support numerous imperiled species. Tule elk (*Cervus elaphus nannodes*), which were once common and widespread throughout the region, were nearly extirpated, but have been reintroduced to several wildlife reserves over recent decades, with one free-roaming population in the Carrizo Plain. Restoring and enhancing connectivity for such species, as well as for aquatic and riparian species, is a high conservation priority in the region.

Due to the highest level of habitat conversion and fragmentation of any ecoregion, the Great Central Valley has a large number of very small Natural Landscape Blocks (Figure 3.5, Table 3.5). The 114 blocks entirely within the ecoregion tend to be very small and isolated, with the smallest average block size of any ecoregion, at <9,000 acres. The largest Natural Landscape Blocks (those > 20,000 acres) are largely restricted to the foothill margins of the Valley proper. These foothill margins are dominated by annual grasslands (55% of Natural Landscape Blocks are mapped as grassland/herbland). The Natural Landscape Blocks in this ecoregion also average a modest Ecological Condition Index of 68, which partly reflects the high proportion of land in nonnative landcovers (28% of Natural Landscape blocks are mapped as urban or agricultural landcovers).

The Natural Landscape blocks are connected by 29 Essential Connectivity Areas (not including 35 Essential Connectivity Areas connecting to other ecoregions), most of which primarily cross agricultural lands. Less than half of the land within Essential Connectivity Areas is in natural landcovers, with 46% in agricultural uses and 5% developed. The balance of the land is in annual grasslands (31%; mostly in the foothills around the Valley) or wetlands and open water (11%; mostly on the Valley floor). The Essential Connectivity Areas consequently average the second lowest Ecological Condition Index of any ecoregion, at only 35. Large expanses of the Great Central Valley lack any significant natural blocks or Essential Connectivity Areas, and there are very few opportunities for maintaining or enhancing cross-Valley connectivity using natural upland vegetation. Consequently, in addition to Essential Connectivity Areas, the remaining riparian corridors play a critical role in helping connect remaining natural areas in the Great Central Valley, a function that can and should be greatly enhanced by riparian and riverine restoration projects.

Some local and regional connectivity planning and implementation has already been done, or is currently being done in the region. For example, the Recovery Plan for Upland Species of the San Joaquin Valley (USFWS 1998) addressed the need to sustain and enhance functional connectivity for various upland species, such as the kit fox, with landscape and "stepping-stone" linkages proposed both on the Valley floor and in the foothills on the Valley's margins. Because few Valley-floor linkages currently exist, the plan also emphasized the need for restoration of continuous corridors, or islands of suitable vegetation to serve as stepping stones for wildlife movements.

Huber (2008) and Huber et al. (2010) developed a conceptual reserve network design for the Central Valley based on least-cost corridor models for a variety of focal species, which focused on the need to restore and enhance suitable habitat in core areas as well as potential


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.5.
CENTRAL VALLEY ECOREGION
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
*Cumulative cost to ecological flows
SACRAMENTO VALLEY
SIERRA NEVADA
SAN JOAQUIN VALLEY
DIABLO RANGE
SALINAS VALLEY
COAST RANGE
TEHACHAPI RANGE
Redding
Sacramento
Stockton
Fresno
Tulare
Bakersfield
Monterey
0 12.5 25 50 75
Kilometers
0 10 20 40 60
Miles
1:2,900,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

linkages between them. This finer-scale conceptual reserve network includes numerous areas that were excluded from our coarse, statewide Essential Habitat Connectivity Map (see Section 3.3.7), once again emphasizing the need for regional and local analyses.

Table 3.5. Mean and standard deviation for metrics in 114 Natural Landscape Blocks and 29 Essential Connectivity Areas wholly within the Great Central Valley Ecoregion. See Table 2.4 for data sources and definitions.

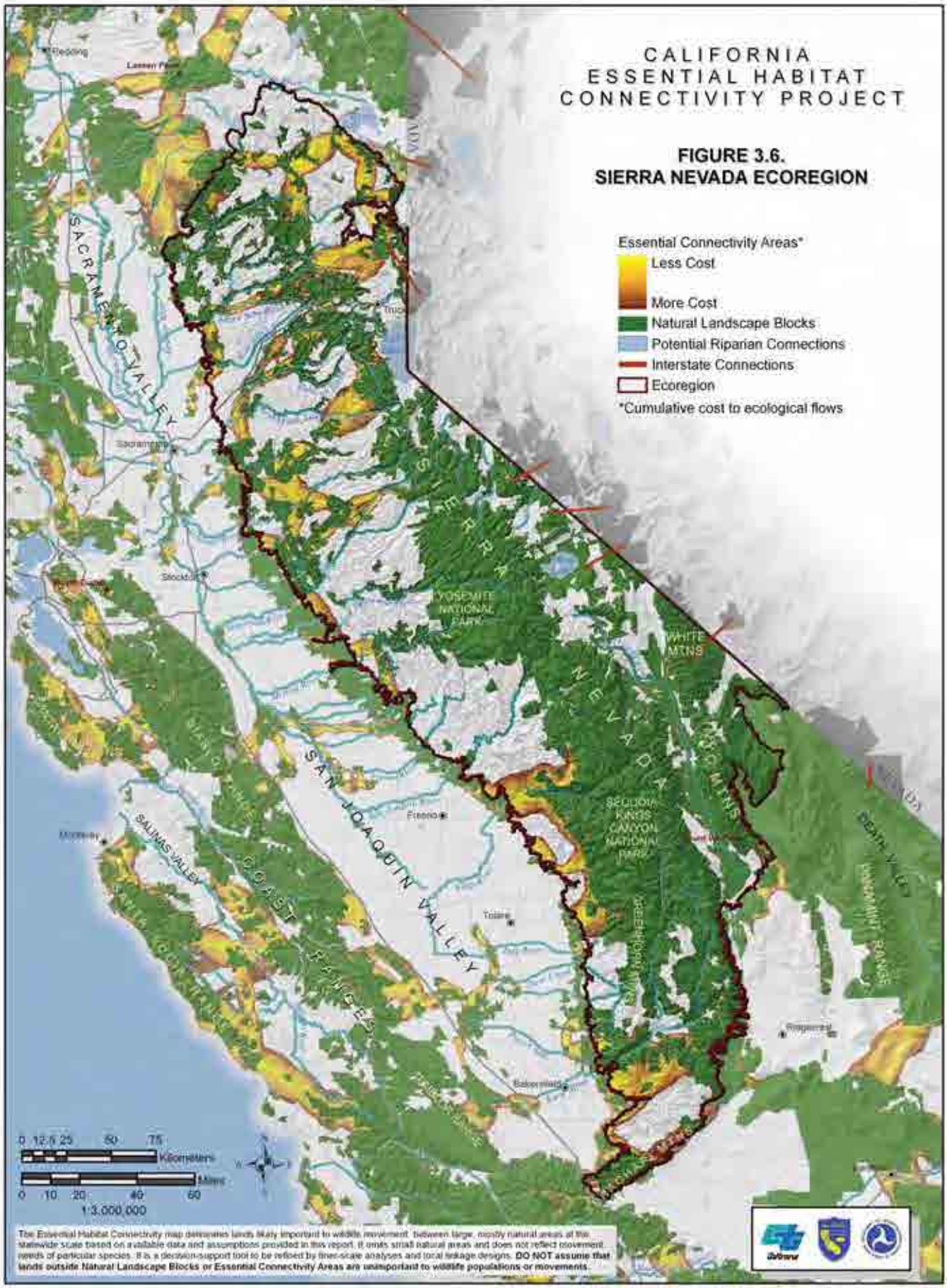
	Descriptor	Mean for 114 Natural Landscape Blocks	Mean for 29 Essential Connectivity Areas
Landform	Elevation (m)	96 (-1 to 627; 108 SD)	79 (-1 to 380; 96 SD)
	Elevation range	86 (1 to 645; 136 SD)	97 (6 to 1,010; 199 SD)
	Mean Ecological Condition Index	68 (0 to 96; 27 SD)	35 (3 to 80; 23 SD)
	Area in acres	8,900 (2,000 to 63,700; 10,700 SD)	22,600 (4,800 to 86,700; 18,300 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	9 (1 to 35; 8 SD)
	Length of least cost path within ECA (km)	Not applicable	13 (2 to 49; 10 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	41 (0 to 100; 42 SD)	20 (0 to 99; 29 SD)
	Percent GAP1, GAP2, or easements	37 (0 to 100; 39 SD)	12 (0 to 72; 19 SD)
	Percent in private, unprotected status	59 (0 to 100; 42 SD)	80 (1 to 100; 29 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	5 (0 to 100; 20 SD)	3 (0 to 71; 14 SD)
Listed species	Percent in USFWS-designated Critical Habitat	25 (0 to 100; 38 SD)	17 (0 to 100; 33 SD)
	Percent in USFWS-mapped essential habitat	32 (0 to 100; 41 SD)	16 (0 to 100; 29 SD)
	Percent in wetland or vernal pool	38 (0 to 100; 37 SD)	21 (0 to 76; 22 SD)
Land Cover	Percent forest and woodland	0 (0 to 1; 0 SD)	0 (0 to 1; 0 SD)
	Percent shrubland, steppe, or savanna	4 (0 to 59; 10 SD)	3 (0 to 49; 9 SD)
	Percent herbaceous	55 (1 to 99; 36 SD)	34 (1 to 98; 30 SD)
	Percent wetland/riparian	11 (0 to 82; 20 SD)	9 (0 to 63; 15 SD)
	Percent open water	1 (0 to 15; 3 SD)	2 (0 to 20; 4 SD)
	Percent developed	3 (0 to 20; 3 SD)	5 (1 to 16; 3 SD)
	Percent cultivated crops	17 (0 to 93; 23 SD)	31 (0 to 69; 22 SD)
	Percent hay/pasture	8 (0 to 81; 16 SD)	15 (0 to 45; 16 SD)
	Percent barren or other	0 (0 to 8; 1 SD)	0 (0 to 4; 1 SD)

A number of extensive restoration projects are planned or underway to improve aquatic flows, remove in-stream barriers, and increase the extent and continuity of riparian vegetation communities along major rivers and tributaries in the Central Valley. For example, the San Joaquin National Wildlife Refuge includes one of California's largest riparian forest restoration projects, creating the largest block of contiguous riparian woodland in the San Joaquin Valley; and conservation and restoration efforts are underway along the Tuolumne, San Joaquin, Cosumnes and other rivers in the region. The focus on restoring ecological functionality in the San Joaquin-Sacramento Bay Delta and the rivers that feed it has also spawned numerous restoration and enhancement projects under the CALFED Ecological Restoration Program and the Bay-Delta Conservation Plan. Finally, various other Natural Community Conservation Plans in the Great Central Valley have focused on, or are currently focusing on, approaches for sustaining, restoring, and enhancing functional connectivity for diverse species and communities (e.g., NCCP/HCP plans in the Counties of Butte, Yolo, Yuba, Sutter, Contra Costa, and Placer).

3.2.5. Sierra Nevada

The Sierra Nevada Ecoregion extends up from the Great Central Valley to the high-elevation peaks of the Sierra Nevada, then plunges abruptly down to Great Basin and desert communities in the great rain shadow that the Sierra Nevada Range casts to the east. The extreme elevation range, long north-south extent, and topographic diversity of the ecoregion makes its natural communities extremely diverse, ranging from grasslands and shrublands on the lower western slopes, up through oak woodlands and highly productive mixed coniferous forests, to subalpine and barren alpine communities at the highest elevations, and then back down through coniferous forests and pinion-juniper woodlands to various desert scrub types to the east. Large areas of the Sierra Nevada are protected as National Parks and wilderness areas, mostly at higher elevations in the southern two-thirds of the range. The more productive timberlands lower down on the western slopes and in the northern Sierra Nevada are a mixture of mostly US Forest Service and private lands that have been historically subject to intensive timber harvest. Outside of the few protected old-growth groves, such as in Yosemite and Sequoia-Kings Canyon National Parks, the ecoregion's forests are generally younger, more even-aged, and less structurally complex than before. This history, coupled with 100 years of intensive fire suppression, has greatly altered fuels conditions and fire regimes—resulting in larger, more frequent, and more severe crown fires than historically occurred. The range is crossed by numerous highways and secondary roads that fragment habitats and represent crossing hazards for wildlife and vehicles alike. Effects of climate change are also evident in the range, with strong upward shifts and expansions in geographic ranges of various species documented over the past century (Moritz et al. 2008).

This large ecoregion has 197 total Natural Landscape blocks, including 118 totally contained within the ecoregion and 79 shared with adjoining ecoregions (Figure 3.6, Table 3.6). The blocks average about 34,000 acres each, with the largest approaching 800,000 acres. Natural Landscape blocks wholly within the ecoregion average a moderately high Ecological Condition Index of 75, are predominantly in shrub (42%) and forest (45%) landcovers, and include a significant amount of riparian and wetland types (6%). The blocks are moderately well protected, with 46% in unprotected private lands, 32% in reserves, and the balance in mostly multiple use federal ownerships, especially National Forests. Many of the Natural


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.6.
SIERRA NEVADA ECOREGION
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
*Cumulative cost to ecological flows
SACRAMENTO VALLEY
SIERRA NEVADA
YOSEMITE NATIONAL PARK
WHITE MTNS
SAN JOAQUIN VALLEY
SEQUOIA KINGS CANYON NATIONAL PARK
SALINAS VALLEY
COAST RANGES
DEATH VALLEY
Redding
Sacramento
Stockton
Fresno
Tulare
Bakersfield
Ridgecrest
0 12.5 25 50 75
Kilometers
0 10 20 40 60
Miles
1:3,000,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Landscape Blocks are separated from neighbors only by a road (the ecoregion has 101 road fragmentation "sticks"), such that there are only 45 total Essential Connectivity Areas connecting Natural Landscape Blocks—16 wholly within the ecoregion and 29 connecting into adjacent ecoregions. The Essential Connectivity Areas wholly within the region are mostly in forest and woodland (57%) or shrub (31%) landcovers. They are generally not well protected, with 59% in private, unprotected status, only 3% in reserves, and most of the balance in multiple-use Forest Service and Bureau of Land Management lands. The Ecological Condition Index in Essential Connectivity Areas is low to moderate, averaging only 51.

Most Essential Connectivity Areas connect between the high-elevation parks and wilderness areas, across multiple-use Forest Service and private lands to Natural Landscape Blocks at lower elevations. Large expanses of the western slope of the Sierra Nevada contain no Natural Landscape Blocks or Essential Connectivity Areas, such that the map shows a lack of north-south connectivity through this region, primarily on National Forests downslope of the large, high-elevation National Parks and Wilderness Areas. These large expanses of forests, woodlands, and chaparral nevertheless support diverse and important biological resources, and there is a need for north-south connectivity along the western slope of the Sierra Nevada to accommodate connectivity for a wide array of species. For example, an isolated population of less than 400 fishers is concentrated within large, old forests at mid elevations, south from Yosemite National Park; and sustaining and enhancing north-south connectivity through this area and expanding suitable habitat to the north of Yosemite is a high conservation priority for sustaining and expanding the population (Spencer et al. 2008). Moreover, Figure 3.6 does not include an Essential Connectivity Area crossing north-south over Interstate 80 in the vicinity of Bear River, an area that is considered an imperiled wildlife linkage (P. Huber, personal communication). Because the Natural Landscape Blocks and Essential Connectivity Areas were delineated based on repeatable rules that could not consider the needs of particular focal species, such omissions must be dealt with in future regional and local connectivity plans (Chapters 4 and 5). Finally, improved road crossings for wildlife (Chapter 6) are a key conservation priority in this ecoregion, not only where roads cross the delineated Natural Landscape Blocks and Essential Connectivity Areas, but also elsewhere.

Table 3.6. Mean and standard deviation for metrics in 118 Natural Landscape Blocks and 16 Essential Connectivity Areas wholly within the Sierra Nevada Ecoregion. See Table 2.4 for data sources and definitions.

	Descriptor	Mean for 118 Natural Landscape Blocks	Mean for 16 Essential Connectivity Areas
Landform	Elevation (m)	1,089 (95 to 2,569; 756 SD)	1,131 (395 to 1,968; 578 SD)
	Elevation range	757 (28 to 3,561; 655 SD)	1,196 (448 to 2,045; 566 SD)
	Mean Ecological Condition Index	75 (0 to 100; 18 SD)	51 (33 to 67; 9 SD)
	Area in acres	33,800 (2,000 to 793,000; 92,800 SD)	73,000 (8,600 to 217,200; 60,800 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	16 (1 to 64; 17 SD)
	Length of least cost path within ECA (km)	Not applicable	21 (3 to 84; 20 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	57 (0 to 100; 40 SD)	41 (0 to 95; 33 SD)
	Percent GAP1, GAP2, or easements	32 (0 to 100; 39 SD)	3 (0 to 21; 6 SD)
	Percent in private, unprotected status	43 (0 to 100; 40 SD)	59 (5 to 100; 33 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	7 (0 to 100; 24 SD)	0 (0 to 0; 0 SD)
Listed species	Percent in USFWS-designated Critical Habitat	1 (0 to 100; 9 SD)	0 (0 to 3; 1 SD)
	Percent in USFWS-mapped essential habitat	21 (0 to 100; 38 SD)	27 (0 to 100; 39 SD)
	Percent in wetland or vernal pool	2 (0 to 95; 10 SD)	1 (0 to 2; 1 SD)
Land Cover	Percent forest and woodland	42 (0 to 97; 38 SD)	57 (1 to 93; 34 SD)
	Percent shrubland, steppe, or savanna	45 (0 to 97; 35 SD)	31 (1 to 80; 32 SD)
	Percent herbaceous	4 (0 to 92; 13 SD)	1 (0 to 12; 3 SD)
	Percent wetland/riparian	6 (0 to 37; 5 SD)	5 (4 to 7; 1 SD)
	Percent open water	0 (0 to 5; 1 SD)	1 (0 to 2; 1 SD)
	Percent developed	0 (0 to 6; 1 SD)	3 (0 to 10; 2 SD)
	Percent cultivated crops	0 (0 to 2; 0 SD)	0 (0 to 2; 1 SD)
	Percent hay/pasture	0 (0 to 2; 0 SD)	1 (0 to 5; 2 SD)
	Percent barren or other	3 (0 to 33; 7 SD)	1 (0 to 5; 1 SD)

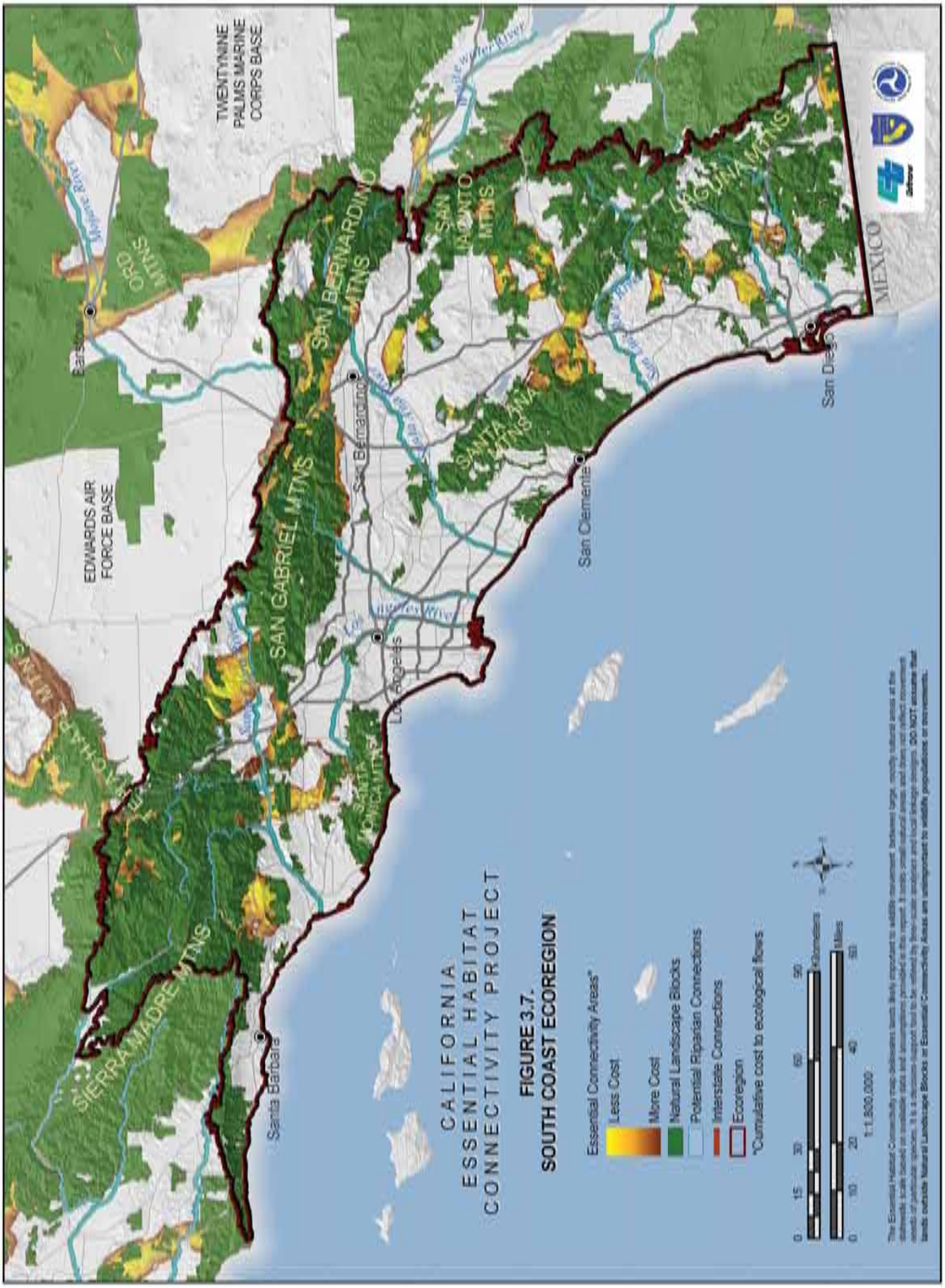
3.2.6. South Coast

The South Coast Ecoregion encompasses roughly 8% of California west of the Sonoran and Mohave deserts and south of the Santa Ynez and Transverse Ranges to the Mexican border. California's most populated ecoregion; it has the dubious distinction of being the most threatened hotspot of biodiversity in the continental United States, with over 400 species of plants and animals considered at risk by government agencies and conservation groups. Despite a human population of over 19 million, the South Coast Ecoregion has many remaining wildland areas, mostly in more rugged mountainous habitats within the Los Padres, Angeles, San Bernardino, and Cleveland National Forests, Santa Monica Mountains National Recreation Area, US Marine Corps Base Camp Pendleton, and several State Parks. It is also one of the most biodiverse regions in the country, with numerous endemic species living in its diverse natural communities, which range from coastal sage scrub and chaparral, to oak and pine woodlands, to desert scrub. These upland communities are punctuated by diverse wetland communities, including vernal pools, estuaries, and riparian scrub and woodlands. In terms of connectivity planning, the South Coast Ecoregion represents a very high-contrast landscape—with most of the conserved blocks in rugged mountainous areas separated by often densely urbanized and agricultural lands on the gentler terrain between them.

The South Coast Ecoregion has 116 Natural Landscape Blocks, including 90 wholly within the ecoregion and 26 shared with adjoining ecoregions. They average only about 23,000 acres and have the lowest average Ecological Integrity Index of any ecoregion, at 52. About 51% of the area within Natural Landscape Blocks is conserved; about 30% is in private, unprotected status; and the balance is mostly in multiple-use federal lands (National Forests and Bureau of Land Management) or military training areas (the largest being US Marine Corps Base Camp Pendleton). About 6% of the area within Natural Landscape Blocks is developed, and about 1% is agriculture. The predominant natural landcovers are shrublands (about 72%; mostly chaparral and coastal sage scrub), herblands (about 10%; mostly annual grasslands), and forests (8%; mostly oak and pine woodlands).

The Natural Landscape Blocks are connected by 27 Essential Connectivity Areas, including 17 wholly within the region and 10 connecting to adjoining ecoregions. As a reflection of the region's large human population, numerous roads, and intensive urbanization, its Essential Connectivity Areas tend to connect Natural Landscape Blocks over less natural landcovers than in any other ecoregion except the Great Central Valley. Only about 82% of the land within Essential Connectivity Areas is in natural landcovers, predominantly shrublands (58% of area). They contain a high level of urban development (12% of area) and a large number of roads (an average of 16 km of major roads and 42 km of secondary roads per Essential Connectivity Area). Consequently, the Essential Connectivity Areas in the South Coast Ecoregion have the lowest average Ecological Condition Index of any ecoregion in the state, at only 26.

Due largely to its high biodiversity and level of habitat loss and fragmentation, the South Coast Ecoregion has arguably experienced more science-based conservation planning, and especially connectivity planning, than any region in the country. It is the birthplace of California's Natural Community Conservation Planning program and has been subject to


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.7.
SOUTH COAST ECOREGION
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
*Cumulative cost to ecological flows
0 15 30 60 90 Kilometers
0 10 20 40 60 Miles
1:1,500,000
TWENTYNINE PALMS MARINE CORPS BASE
EDWARDS AIR FORCE BASE
SIERRA MADRE MTNS
SAN GABRIEL MTNS
SAN BERNARDINO MTNS
SAN JACINTO MTNS
SANTA ANA MTNS
LAGUNA MTNS
ORO MTNS
SANTA MONICA MTNS
Santa Barbara
Barstow
San Bernardino
Los Angeles
San Clemente
San Diego
MEXICO

numerous regional Habitat Conservation Plans/Natural Community Conservation Plans over the past two decades. The ecoregion has been intensively studied at regional and local scales for the effects of habitat fragmentation on natural communities and species, and for approaches to sustaining and restoring ecological connectivity to counter these effects (e.g., Beier 1993, Beier et al. 2006, Bolger et al. 1997, Crooks 2002, Riley et al. 2003, Soule et al. 1988, Vandergast et al. 2008). It has also been the focus of intensive, collaborative habitat connectivity planning over the past decade via the South Coast Missing Linkages Project, which has developed 11 detailed and implementable Linkage Designs using focal-species based analyses (Beier et al. 2006, Luke et al. 2004, Penrod et al. 2003, 2004a, 2004b, 2005a, 2005b, 2005c, 2006a, 2006b, 2006c, 2006d; http://scwildlands.org/reports/). When stitched together, these Linkage Designs form an ecoregional connectivity conservation plan. Ten of the 11 Linkage Designs are being actively implemented by cooperating groups of agencies, non-governmental organizations, and other stakeholders.

The South Coast Missing Linkages approach can serve as an example to be repeated and improved upon in other Ecoregions in California and elsewhere. The statewide Essential Habitat Connectivity Network may correspond with local-scale, focal-species Linkage Designs, showing that it captured 81% of the area within the Linkage Designs of the South Coast Missing Linkages Project (Section 3.3.8). Thus, despite the limitations of the coarse, statewide approach used to develop the Essential Habitat Connectivity Map, the Essential Connectivity Areas appear to represent a reasonable first approximation of those areas likely to be included in local Linkage Designs, at least in such high-contrast landscapes as the South Coast Ecoregion.

In addition to the Linkage Designs in the California portion of the South Coast Ecoregion, there are several potential connections to wildland areas in Baja California, Mexico (not mapped). Cross-border planning with Mexican agencies and non-governmental organizations is happening in these areas via the Las Californias Binational Conservation Initiative[23] However, continued development of border fencing to stem illegal immigration presents a major challenge to cross-border connectivity planning.

Future connectivity conservation efforts in the South Coast Ecoregion should continue focusing on implementing the existing 11 Linkage Designs of the South Coast Missing Linkages Project and developing similar Linkage Designs for other Essential Connectivity Areas. Numerous opportunities also exist for road-crossing improvements in the region. Caltrans is currently evaluating road-crossing improvement as part of transportation projects along Highway 101 near Liberty Canyon and along the 118 freeway near Alamos Canyon in the Santa Monica-Sierra Madre Connection (Penrod et al. 2006a), which have long been identified as critical for maintaining connectivity in the region (Soulé 1989, Sauvajot et al. 2000, Riley et al. 2003, Ng et al. 2004, LSA 2004, Riley et al. 2005, Riley et al. 2006). One location that has been long-proposed as a high priority for construction of a wildlife overpass is across Interstate 15 between the Santa Ana Mountain Range and the Palomar Mountain Range near the Riverside County/San Diego County boundary. This is a critical pinch-point in the Santa Ana-Palomar Linkage Design (Luke et al. 2004)—and also within an Essential Connectivity Area—where mountain lions are frequently killed by vehicles (Beier 1995) and

[23] http://consbio.org/what-we-do/las-californias-binational-conservation-initiative/?searchterm=las%20californias.

numerous biologists and stakeholders determined an overpass structure would facilitate population and genetic connectivity for numerous species between otherwise isolated reserve areas (Luke et al. 2004).

Table 3.7. Mean and standard deviation for metrics in 90 Natural Landscape Blocks and 17 Essential Connectivity Areas wholly within the South Coast Ecoregion. See Table 2.4 for data sources and definitions.

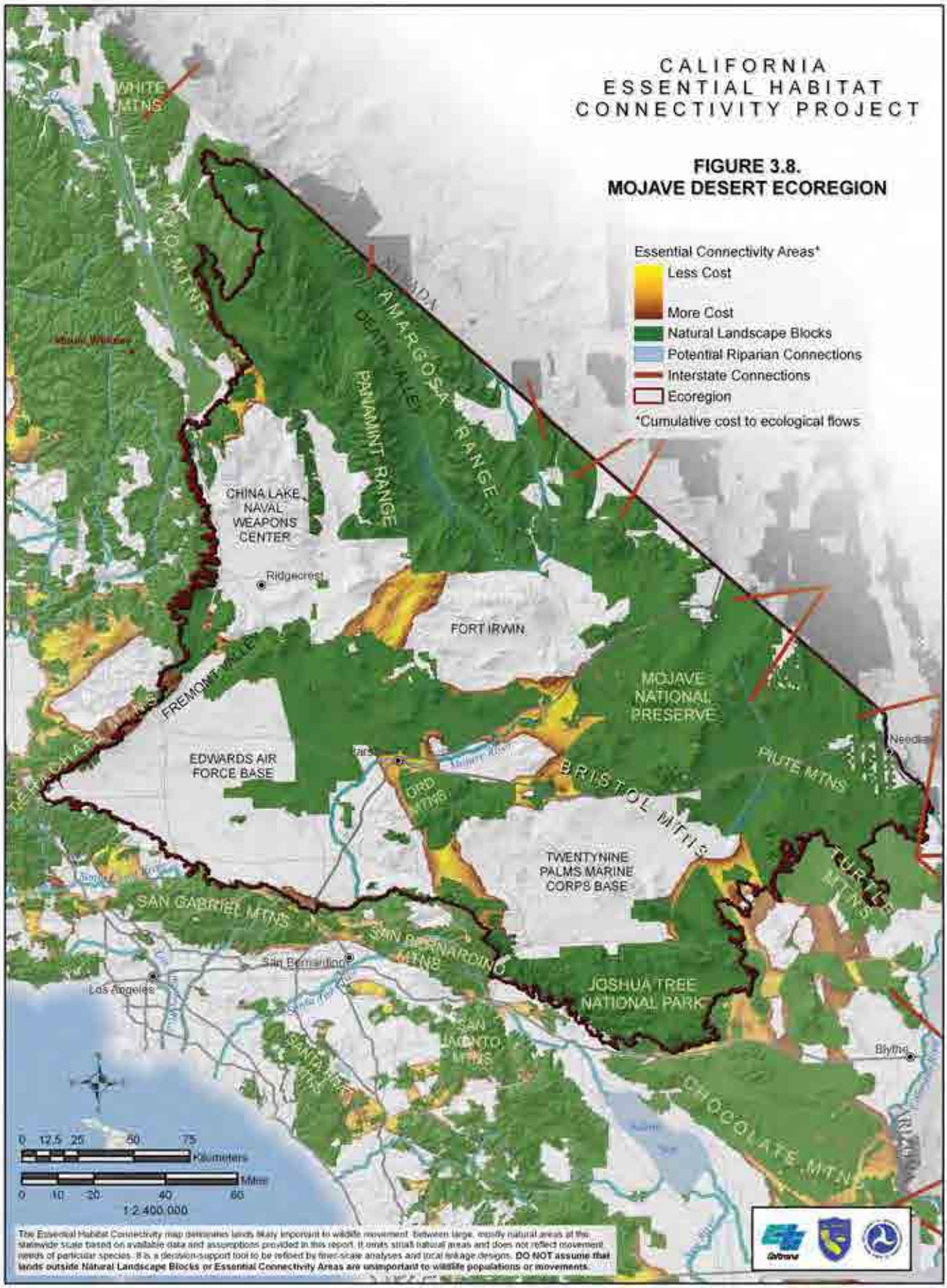
	Descriptor	Mean for 90 Natural Landscape Blocks	Mean for 17 Essential Connectivity Areas
Landform	Elevation (m)	612 (17 to 1,721; 380 SD)	561 (95 to 1,448; 288 SD)
	Elevation range	661 (42 to 2,561; 461 SD)	859 (184 to 1,799; 434 SD)
	Mean Ecological Condition Index	52 (0 to 96; 33 SD)	26 (5 to 51; 14 SD)
	Area in acres	23,400 (2,000 to 437,000; 53,000 SD)	34,000 (4,400 to 119,000; 34,600 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	9 (0.1 to 36; 9 SD)
	Length of least cost path within ECA (km)	Not applicable	13 (0.1 to 43; 10 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	70 (0 to 100; 33 SD)	28 (1 to 81; 26 SD)
	Percent GAP1, GAP2, or easements	51 (0 to 100; 40 SD)	10 (0 to 36; 11 SD)
	Percent in private, unprotected status	30 (0 to 100; 33 SD)	72 (19 to 99; 26 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	33 (0 to 100; 43 SD)	44 (0 to 100; 45 SD)
Listed species	Percent in USFWS-designated Critical Habitat	15 (0 to 96; 28 SD)	19 (0 to 54; 17 SD)
	Percent in USFWS-mapped essential habitat	33 (0 to 100; 38 SD)	20 (0 to 77; 24 SD)
	Percent in wetland or vernal pool	1 (0 to 42; 5 SD)	1 (0 to 2; 1 SD)
Land Cover	Percent forest and woodland	8 (0 to 86; 15 SD)	6 (0 to 45; 11 SD)
	Percent shrubland, steppe, or savanna	72 (1 to 93; 20 SD)	58 (4 to 85; 21 SD)
	Percent herbaceous	10 (0 to 42; 9 SD)	15 (4 to 41; 11 SD)
	Percent wetland/riparian	2 (0 to 43; 6 SD)	1 (0 to 3; 1 SD)
	Percent open water	0 (0 to 11; 2 SD)	1 (0 to 4; 1 SD)
	Percent developed	6 (1 to 32; 6 SD)	12 (6 to 19; 4 SD)
	Percent cultivated crops	1 (0 to 25; 4 SD)	5 (0 to 65; 16 SD)
	Percent hay/pasture	0 (0 to 17; 2 SD)	1 (0 to 14; 3 SD)
	Percent barren or other	1 (0 to 12; 1 SD)	1 (0 to 5; 1 SD)

3.2.7. Mojave Desert

The Mojave Desert Ecoregion is a vast arid area in the rain shadow of the southern Sierra Nevada and the Transverse and Peninsular Ranges. It is home to dramatic geological features—including numerous mountain ranges, washes, cliffs, and sand dunes—and is dotted with scattered springs, seeps, and other oases that serve diverse wildlife and endemic plants. Two major riparian corridors—associated with the Amargosa River in the north and the Mojave River in the south—are major arteries of life for the region's diverse wildlife, including a variety of endemic species. However, these and other oases are severely threatened by groundwater pumping, grazing, and other stressors.

The Mojave is 80% managed by federal agencies, and boasts some of the state's largest reserve areas, including Death Valley National Park, Mojave National Preserve, and Joshua Tree National Park. The Bureau of Land Management is the largest land manager in the region, overseeing 8 million acres. The Department of Defense manages five large military bases, which cover about 13% of the ecoregion. Although ecological integrity is severely degraded in portions of these bases due to development and heavy use for military training, other large areas receive little to no use and represent some of the most pristine and intact natural areas in the desert, because they are protected against off-road vehicle use, mining, grazing, and other stressors that have widely degraded habitats on other lands. Most of the 18% of the region that is in unprotected private ownership is concentrated in the western Mojave, which has experienced tremendous urban sprawl and associated habitat loss and fragmentation over recent decades. Highways through the desert are a significant threat to such species as the threatened Mojave desert tortoise (*Gopherus agassizi*). The recent push to greatly increase California's production of renewable energy has also raised concerns that massive solar power developments and associated infrastructure will convert and fragment large areas of native habitat. Sustaining and enhancing habitat connectivity in the face of energy development, urban sprawl, transportation improvements, off-road vehicle use, and other stressors is a major conservation concern in the Mojave. Populations of many of the region's rare and endemic species—such as the desert tortoise, Mohave ground squirrel (*Spermophilus mohavensis*), and desert bighorn sheep (*Ovis canadensis*)—are becoming increasingly isolated from one another, leading to decreased genetic diversity and risk of extirpations.

Due to the large size of existing reserve areas in this ecoregion, relatively few Natural Landscape Blocks and Essential Connectivity Areas were delineated here—although they tend to be very large, ecologically intact, and well-protected (Table 3.8). The ecoregion fully contains 52 Natural Landscape Blocks and shares 27 others with adjacent ecoregions. The Natural Landscape Blocks within the ecoregion have the highest average size (more than 135,000 acres), highest average Ecological Condition Index (89), and highest level of conservation protection (94) of those in any ecoregion. Some Natural Landscape Blocks, such as those associated with the Mojave National Preserve and Death Valley National Park, exceed 1 million acres. The high Ecological Condition Index reflects the region's scarcity of urban and agricultural landcovers and low road density. However, it should be noted that the Ecological Condition Index was unable to reflect such impacts as grazing, mining, invasive plants, and off-road vehicle use, and desert communities are notoriously fragile and slow to recover from such stressors.


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.8.
MOJAVE DESERT ECOREGION
Essential Connectivity Areas*
Less Cost
More Cost
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
*Cumulative cost to ecological flows
WHITE MTNS
AMARGOSA RANGE
DEATH VALLEY
PANAMINT RANGE
CHINA LAKE NAVAL WEAPONS CENTER
Ridgecrest
FORT IRWIN
MOJAVE NATIONAL PRESERVE
FREMONT VALLEY
EDWARDS AIR FORCE BASE
Barstow
ORD TRNG
BRISTOL MTNS
PIUTE MTNS
Needles
TWENTYNINE PALMS MARINE CORPS BASE
SAN GABRIEL MTNS
SAN BERNARDINO MTNS
San Bernardino
Los Angeles
JOSHUA TREE NATIONAL PARK
SAN JACINTO MTNS
Blythe
CHOCOLATE MTNS
0 12.5 25 50 75
Kilometers
0 10 20 40 60
Miles
1:2,400,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

The five large military bases in the region were almost entirely excluded from the Natural Landscape Blocks, and they represent some of the large "holes" in this Ecoregion's Essential Habitat Connectivity network (Figure 3.8)—despite that large portions of some bases are quite ecologically pristine and support diverse native species. This exclusion occurred because these bases are not considered ecological reserves (i.e., they are in GAP 3 conservation status) and are not included in the data layers used to define High Biological Values (e.g., Critical Habitat or BLM Areas of Critical Environmental Concern)[24]. However, the military has been an active partner in efforts to manage their lands for biological values and to maintain functional ecological connectivity on and across their lands. Ongoing regional and local planning is addressing such issues, and the results should be used to rectify this limitation of the Essential Habitat Connectivity Map.

Similar to the region's Natural Landscape Blocks, Essential Connectivity Areas mapped here average the largest (mean size over 300,000 ac), and best protected (45% in reserve status) of those in any ecoregion, and are second only to the Sonoran Desert Ecoregion in average Ecological Condition Index (80). Again, however, much of the land included within Essential Connectivity Areas is designated multiple-use by the Bureau of Land Management, and subject to such stressors as off-road vehicle use (both legal and unsanctioned), grazing (by livestock as well as feral horses and burros), and mining. Moreover, these Bureau of Land Management lands are under intense pressure for renewable energy development, which could convert and fragment substantial acreages.

There are a number of important conservation and land-use planning efforts already completed or underway in the Mojave Desert Ecoregion, including the California Desert Conservation Area Plan, the Desert Tortoise Recovery Plan, and the Northern, Eastern, and Western Mojave Plans (Bunn et al. 2007). Numerous government agencies, landowners, and conservation non-governmental organizations are very active in wildlife conservation efforts in the region, including the Conservation Fund, The Nature Conservancy, Preserving Wild California, and the interagency Desert Managers Group (See Bunn et al. 2007 for more details). California's Resources Agency, in partnership with other state and federal agencies, also recently initiated the Desert Renewable Energy Conservation Plan (DRECP) to address the impacts of proposed renewable energy developments on rare, Threatened and Endangered Species throughout California's deserts.

Finally, there is also a recently initiated regional connectivity-planning effort—the California Desert Connectivity Project—that is delineating 23 Linkage Designs for 47 target species between wildland blocks throughout California's deserts, using methods similar to those presented in Chapters 4 and 5 of this Report. Unlike this statewide Essential Habitat Connectivity Project, that regional plan specifically targets Gap 3 lands—such as the region's large military bases and Bureau of Land Management holdings—in addition to Gap 1 and 2 reserve areas as potential Natural Wildland Blocks. Thus, landscape blocks and linkages delineated by that finer-scale and evolving regional plan should be used to replace Figure 3.8

[24] Recall that Natural Landscape Blocks were delineated in this region only if they enjoyed high conservation protection (GAP 1 and 2 lands or conservation easements) OR they scored very high (>95) in Ecological Condition Index AND were mapped as having High Biological Value (Section 2.1).

when the results are available. See Section 3.3.10 for a more detailed description of that planning effort.

Table 3.8. Mean and standard deviation for metrics in 52 Natural Landscape Blocks and 7 Essential Connectivity Areas wholly within the Mojave Desert Ecoregion. See Table 2.4 for data sources and definitions.

	Descriptor	Mean for 52 Natural Landscape Blocks	Mean for 7 Essential Connectivity Areas
Landform	Elevation (m)	850 (169 to 1,360; 253 SD)	887 (701 to 1,610; 328 SD)
	Elevation range	879 (83 to 3,442; 752 SD)	1,109 (409 to 1,770; 571 SD)
	Mean Ecological Condition Index	89 (64 to 100; 8 SD)	80 (48 to 96; 17 SD)
	Area in acres	135,400 (2,100 to 1,087,600; 247,800 SD)	312,100 (12,700 to 1,035,600; 389,600 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	30 (0.1 to 75; 35 SD)
	Length of least cost path within ECA (km)	Not applicable	38 (0.1 to 89; 41 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	99 (85 to 100; 2 SD)	87 (53 to 99; 17 SD)
	Percent GAP1, GAP2, or easements	94 (0 to 100; 15 SD)	45 (1 to 92; 33 SD)
	Percent in private, unprotected status	1 (0 to 15 2 SD)	13 (1 to 47; 17 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	10 (0 to 100; 25 SD)	1 (0 to 4; 1 SD)
Listed species	Percent in USFWS-designated Critical Habitat	33 (0 to 100; 41 SD)	11 (0 to 32; 12 SD)
	Percent in USFWS-mapped essential habitat	0 (0 to 0; 0 SD)	0 (0 to 0; 0 SD)
	Percent in wetland or vernal pool	0 (0 to 7; 1 SD)	0 (0 to 0; 0 SD)
Land Cover	Percent forest and woodland	0 (0 to 6; 1 SD)	2 (0 to 17; 6 SD)
	Percent shrubland, steppe, or savanna	64 (24 to 100; 20 SD)	58 (24 to 90; 21 SD)
	Percent herbaceous	0 (0 to 12; 2 SD)	0 (0 to 0; 0 SD)
	Percent wetland/riparian	0 (0 to 17; 3 SD)	5 (0 to 26; 9 SD)
	Percent open water	0 (0 to 0; 0 SD)	0 (0 to 0; 0 SD)
	Percent developed	0 (0 to 2; 0 SD)	3 (0 to 11; 4 SD)
	Percent cultivated crops	0 (0 to 1; 0 SD)	0 (0 to 0; 0 SD)
	Percent hay/pasture	0 (0 to 0; 0 SD)	0 (0 to 0; 0 SD)
	Percent barren or other	34 (0 to 74; 20 SD)	32 (7 to 57; 16 SD)

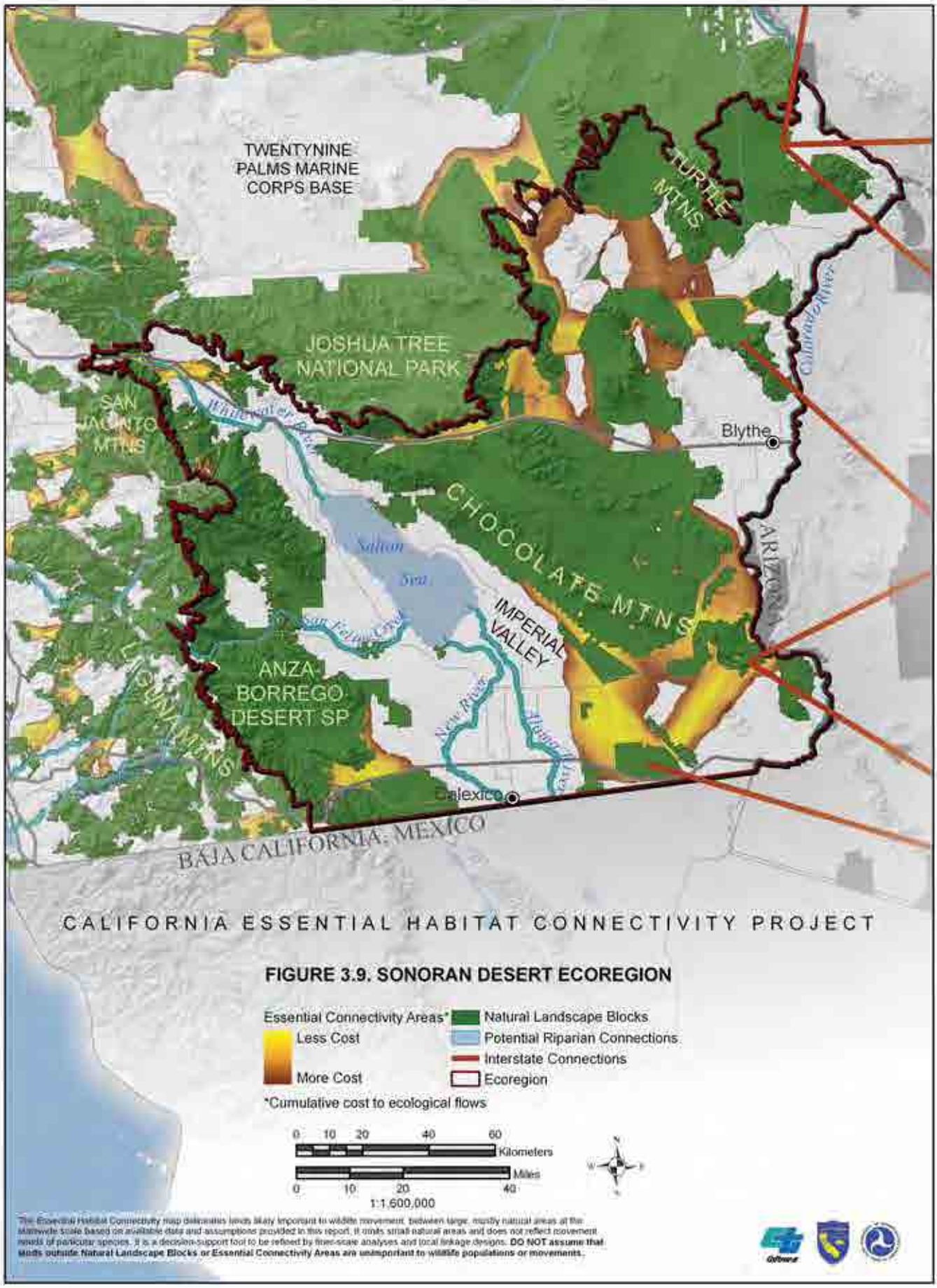
3.2.8. Sonoran Desert

The portion of the Sonoran Desert in California, which is also known as the Colorado Desert, encompasses about 7 million acres between the Peninsular Mountain Range and the Colorado River, south from about Palm Springs, Joshua Tree National Park, and the Turtle Mountains to the Mexican border. This ecoregion differs from the Mojave Desert Ecoregion in being of generally lower elevation, with higher average day-time temperatures, and with two rather than one rainy seasons (whereas nearly all rain in the Mojave falls as gentle winter rains, the Sonoran Desert tends to also receive some late summer rains). This variation makes for a different mix of plant communities (including some endemic communities like fan palm oases), as well as a diverse and somewhat unique fauna. This ecoregion also has several large sand dune systems, including the Algodones Dunes east of Imperial Valley (about 160,000 acres), the Superstition Hills (about 100,000 acres), and the Coachella Valley dunes (once about 64,000 acres, but greatly diminished to only about 8,000 acres due to development that blocks the blowing sands needed to replenish the system). The remaining dune areas provide habitat for a diversity of endemic species that are threatened by off-road vehicle use and disruption of natural sand movements.

The Bureau of Land Management is the region's largest land manager, with about 43% of the ecoregion. Department of Defense lands account for about 7% and Anza-Borrego Desert State Park about 9%. This ecoregion is one of the least populated by humans, with the greatest concentrations of human occupancy and land conversion along the Colorado River in the east and in the Coachella Valley, Imperial Valley, and Borrego Springs in the west. Similar to the Mojave Desert, threats to ecological integrity in the Sonoran include water diversion and ground-water pumping, off-road vehicle use, increasing urbanization (especially in the Coachella Valley and southern Imperial County), renewable energy development, mining, invasive species, and grazing, especially by burros.

The Sonoran Desert Ecoregion has 37 Natural Landscape Blocks, including 25 wholly within the region and 12 shared with other ecoregions. The 25 Natural Landscape Blocks within the ecoregion are on average very large at over 87,400 acres, and they average a very high Ecological Condition Index of 84. However, as in the Mojave, this apparent high level of ecological integrity reflects the paucity of urban and agricultural landcovers and the low number of roads, but it does not account for effects of such stressors as off-road vehicle use, grazing, mining, invasive plants, and disruption of sand-dune replenishment. The Natural Landscape Blocks are primarily in reserves (79%), with only 3% of their area being in private, unprotected status, and the balance mostly being under multiple use management.

The Natural Landscape Blocks are connected by 13 Essential Connectivity Areas, including five wholly contained within the region and eight shared with adjoining regions. The Essential Connectivity Areas are mostly on Bureau of Land Management holdings managed for multiple uses, with only 15% in reserve status and 6% in private, unprotected status. These Essential Connectivity Areas are second only to the Mojave in their average size, at about 119,000 acres, and have the highest Ecological Integrity Index of those in any ecoregion, at 93. The ecoregion is unique in that the Essential Connectivity Areas scored a higher average Ecological Condition Index than the Natural Landscape Blocks they connect, but this could be an artifact of the relatively small sample size and the fact that the Ecological


TWENTYNINE PALMS MARINE CORPS BASE
JOSHUA TREE NATIONAL PARK
TURTLE MTNS
Colorado River
SAN JACINTO MTNS
Whitewater River
Blythe
CHOCOLATE MTNS
Salton Sea
San Felipe Creek
IMPERIAL VALLEY
ARIZONA
ANZA BORREGO DESERT SP
SUNA MTNS
New River
Alamo River
Calexico
BAJA CALIFORNIA, MEXICO
CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT
FIGURE 3.9. SONORAN DESERT ECOREGION
Essential Connectivity Areas*
Less Cost
More Cost
*Cumulative cost to ecological flows
Natural Landscape Blocks
Potential Riparian Connections
Interstate Connections
Ecoregion
0 10 20 40 60
Kilometers
Miles
0 10 20 40
1:1,600,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement, between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Condition Index does not account for the effects of various stressors, like off-road vehicles. Nevertheless, the Sonoran Desert Ecoregion, similar to the Mojave Desert Ecoregion, represents a "low-contrast" landscape for connectivity planning, where the primary focus may be on managing lands in Essential Connectivity Areas for continued compatibility with support of biological resources and landscape permeability to wildlife movement. This focus should include siting renewable energy projects to not block potential wildlife movement corridors (e.g., between mountains occupied by bighorn sheep) or otherwise disrupt ecological flows. Bighorn sheep need to be able to move between subpopulations (or ewe groups) to allow genetic exchange and maintain a viable population structure; and habitat fragmentation can result in genetic isolation and restrict the species' ability to recolonize if subpopulations are lost (Bunn et al. 2007). Management should also focus on improving road-crossing structures, coupled with roadside fencing designed to keep desert tortoise and other species off roads. As mentioned above, the California Desert Connectivity Project will be developing fine scale Linkage Designs for this ecoregion, which will complement Natural Landscape Blocks and Essential Connectivity Areas identified in Figure 3.9.

Table 3.9. Mean and standard deviation for metrics in 25 Natural Landscape Blocks and 5 Essential Connectivity Areas wholly within the Sonoran Desert Ecoregion. See Table 2.4 for data sources and definitions.

	Descriptor	Mean for 25 Natural Landscape Blocks	Mean for 5 Essential Connectivity Areas
Landform	Elevation (m)	193 (-65 to 410; 147 SD)	152 (41 to 272; 93 SD)
	Elevation range	425 (14 to 1,627; 486 SD)	449 (169 to 678; 214 SD)
	Mean Ecological Condition Index	84 (0 to 100; 26 SD)	93 (87 to 100; 6 SD)
	Area in acres	87,400 (2,100 to 1,125,200; 227,900 SD)	119,000 (6,600 to 217,800; 91,400 SD)
ECA	Shortest straight line within ECA between edges of NLBs (km)	Not applicable	12 (1 to 19; 10 SD)
	Length of least cost path within ECA (km)	Not applicable	15 (1 to 29; 12 SD)
Protection Status	Percent GAP 1, GAP2, GAP3 or easements	97 (86 to 100; 4 SD)	94 (84 to 100; 6 SD)
	Percent GAP1, GAP2, or easements	79 (0 to 100; 34 SD)	15 (0 to 67; 29 SD)
	Percent in private, unprotected status	3 (0 to 14; 4 SD)	6 (0 to 16; 6 SD)
	Percent of polygon in amphibian, reptile, mammal, or plant rarity hotspot	1 (0 to 18; 4 SD)	0 (0 to 2; 1 SD)
Listed species	Percent in USFWS-designated Critical Habitat	31 (0 to 100; 37 SD)	6 (0 to 27; 12 SD)
	Percent in USFWS-mapped essential habitat	4 (0 to 99; 20 SD)	1 (0 to 2; 1 SD)
	Percent in wetland or vernal pool	0 (0 to 2; 0 SD)	0 (0 to 0; 0 SD)
Land Cover	Percent forest and woodland	0 (0 to 2; 0 SD)	0 (0 to 0; 0 SD)
	Percent shrubland, steppe, or savanna	54 (1 to 97; 26 SD)	41 (1 to 88; 34 SD)
	Percent herbaceous	0 (0 to 4; 1 SD)	0 (0 to 0; 0 SD)
	Percent wetland/riparian	15 (0 to 69; 16 SD)	20 (1 to 45; 23 SD)
	Percent open water	1 (0 to 23; 5 SD)	0 (0 to 0; 0 SD)
	Percent developed	0 (0 to 3; 1 SD)	1 (0 to 1; 1 SD)
	Percent cultivated crops	1 (0 to 17; 3 SD)	0 (0 to 1; 0 SD)
	Percent hay/pasture	1 (0 to 22; 4 SD)	0 (0 to 1; 0 SD)
	Percent barren or other	28 (0 to 99; 24 SD)	38 (8 to 98; 35 SD)

3.3. Comparison of the Essential Habitat Connectivity Map to Other Conservation Maps

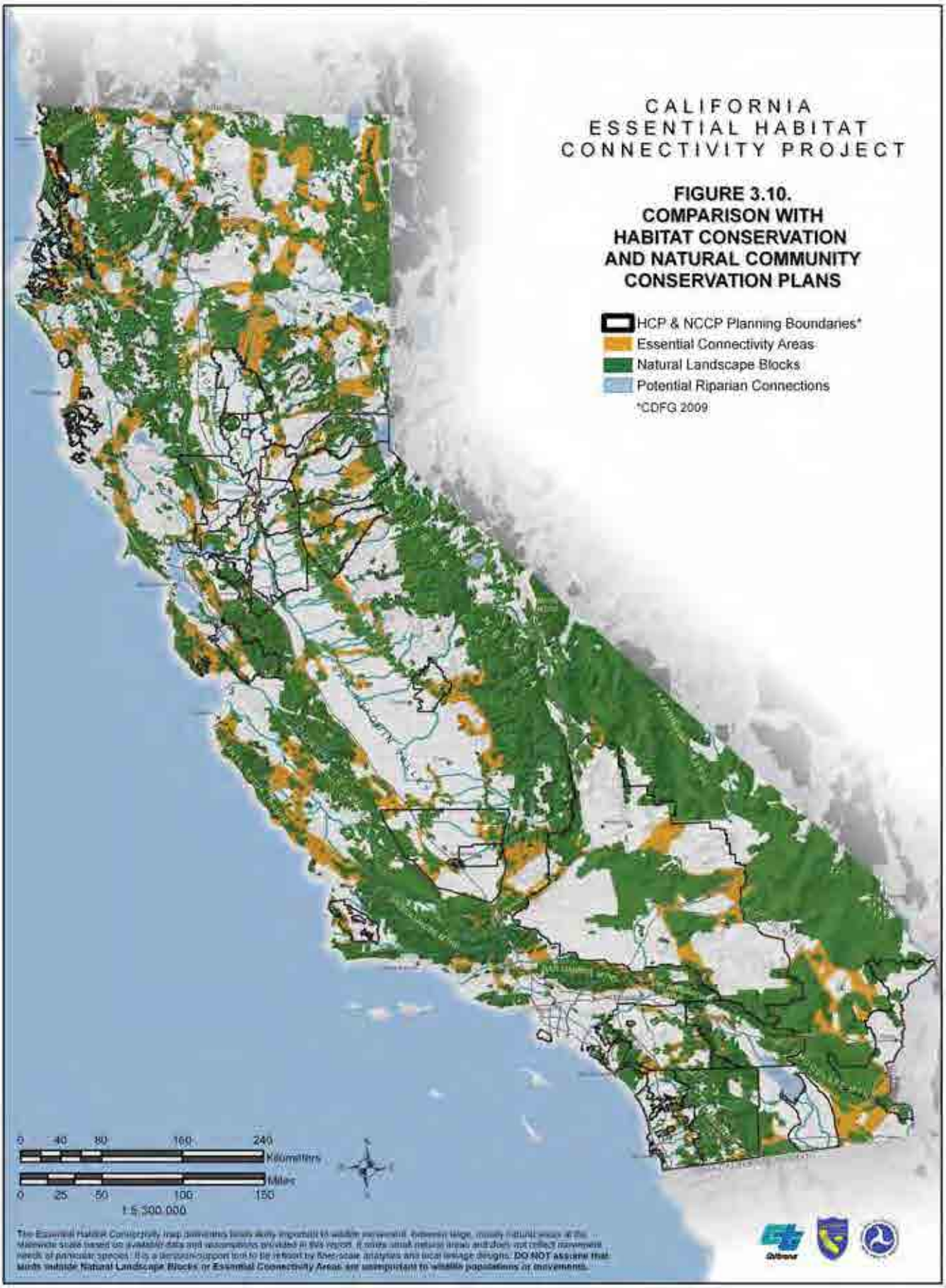
Here we compare the statewide network of Natural Landscape Blocks and Essential Connectivity Areas to relevant maps and data produced by other conservation planning efforts throughout California. This comparison is not exhaustive, but illustrates how the statewide network may complement other planning efforts. This comparison is by its very nature "apples to oranges," such that one should not necessarily expect close correspondence between the Essential Connectivity Map and maps created using different approaches for different objectives. However, where there is concordance between the maps, it reveals potential opportunities for synergistic achievement of conservation goals.

3.3.1. Habitat Conservation and Natural Community Conservation Plans

Habitat Conservation Plans are intended to integrate land-use activities and conservation goals and reduce conflicts between listed species and economic development; they are also required as part of an application for an incidental take permit (i.e., Section 10 (a)(1)(B) of the Endangered Species Act; USFWS 2005). California Department of Fish and Game's Natural Community Conservation Planning program (dfg.ca.gov/habcon/nccp) is an effort by the State to work cooperatively with numerous private and public partners to develop regional or area-wide networks to protect natural ecological communities and their constituent species. The program, which began in 1991 as an experimental program for the South Coast Ecoregion, was later expanded to the entire state with the Natural Community Conservation Planning Act of 2003. It is broader in its orientation and objectives than the California and Federal Endangered Species Acts, which focus on individual species rather than natural communities. While all Natural Community Conservation Plans are also Habitat Conservation Plans, the reverse is not necessarily true.

There are 39 Habitat Conservation Plans throughout the state, 17 which have been approved and are being implemented and 22 that are in the planning stages. Eight of the 17 Habitat Conservation Plans that have been approved and are being implemented are Natural Community Conservation Plans, while 16 of the 22 Habitat Conservation Plans that are in the planning stages are Natural Community Conservation Plans (Figure 3.10). Collectively, the boundaries for these large-scale regional conservation planning efforts cover 28.0 million acres throughout the state.

The California Essential Habitat Connectivity Project network of Natural Landscape Blocks and Essential Connectivity Areas covers 41% of the total area covered by Habitat Conservation Plans and Natural Community Conservation Plans, and only two (Natomas Basin HCP and Palos Verdes Peninsula NCCP/HCP) were not overlapped at all by the network (Table 3.10). The smaller NCCP/HCP planning areas were likely not captured due to the size criteria applied for delineating Natural Landscape Blocks. The relatively low portion (41%) captured by the network is reasonable since this comparison used only the NCCP/HCP planning boundaries, which often encompass large areas of non-habitat. NCCP/HCPs that are currently in the planning phase and future NCCP/HCPs can utilize the


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.10.
COMPARISON WITH
HABITAT CONSERVATION
AND NATURAL COMMUNITY
CONSERVATION PLANS
HCP & NCCP Planning Boundaries*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*CDFG 2009
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000
The Essential Habitat Connectivity map delineates areas likely important to wildlife movement, between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Essential Habitat Connectivity Map and guidelines as a decision-support tool for planning for connectivity within and beyond their planning boundaries.

Table 3.10. Overlap between Natural Landscape Blocks (NLB) and Essential Connectivity Areas (ECA) with Habitat Conservation Plans (HCP) and Natural Community Conservation Plans (NCCP).

NAME	HCP or NCCP Area (acres)	NLB acres in HCP or NCCP	ECA acres in HCP or NCCP	Percent of HCP/NCCP in NLB/ECA
Altamont Pass Wind Resource Area NCCP/HCP	58,785	37,311	7,116	76%
Bay/Delta Conservation Plan NCCP/HCP	947,105	155,377	63,735	23%
Butte County NCCP/HCP	564,487	107,314	37,712	26%
Calaveras County NCCP/HCP	662,838	253,755	157,419	62%
Central Coastal Orange NCCP/HCP	108,718	58,590	0	54%
Coachella Valley MSHCP NCCP/HCP	1,206,713	696,639	75,379	64%
East Contra Costa County NCCP/HCP	174,042	76,337	0	44%
East Fresno HCP	288,794	68,521	57,302	44%
El Dorado County NCCP/HCP	1,144,943	310,689	222,181	47%
Green Diamond HCP	451,566	68,403	120,614	42%
Humboldt Redwoods Company HCP	200,967	5,867	49,607	28%
Imperial Irrigation District NCCP/HCP	592,481	6,316	8,072	2%
Kern County Valley Floor HCP	1,802,148	441,065	202,441	36%
Kern Water Bank HCP	19,986	977	17,683	93%
Los Osos HCP	3,382	252	436	20%
Lower Colorado River MSCP HCP	1,227,345	576,222	103,533	55%
Mendocino Redwood Company NCCP/HCP	213,435	1,000	7,026	4%
Metropolitan Bakersfield HCP	208,430	13,668	12,282	12%
Natomas Basin HCP	53,158	0	0	0%
Orange County Southern Subregion HCP	124,688	60,829	4	49%
Palos Verdes Península NCCP/HCP	24,815	0	0	0%
Placer County Conservation Plan NCCP/HCP Phase I	244,227	18,296	50,957	28%
Placer County Conservation Plan NCCP/HCP Phase II and III	960,105	287,902	157,680	46%
San Diego E. County MSCP NCCP/HCP	1,538,154	1,203,998	29,596	80%
San Diego MSHCP NCCP/HCP	119,124	3,354	2,624	5%
San Diego MSCP NCCP/HCP	544,505	141,542	42,774	34%
San Diego N.County MSCP NCCP/HCP	353,064	89,849	45,162	38%
San Joaquin County HCP	912,593	145,807	31,428	19%
Santa Barbara Multi-Species HCP	247,530	44,245	31,639	31%
Santa Clara Valley NCCP/HCP	515,217	281,385	91,166	72%
Santa Cruz Sandhills HCP	6,612	1,455	3,951	82%
Solano Multi-Species HCP	582,367	123,155	65,918	32%
South Sacramento HCP	341,314	113,331	36,779	44%
West Mojave Coordinated Management Plan HCP	9,249,223	2,814,589	781,711	39%
Western Riverside MSHCP NCCP/HCP	1,251,450	387,984	139,965	42%
Yolo County Heritage Program NCCP/HCP	653,447	193,206	62,815	39%
Yuba-Sutter NCCP/HCP	445,144	15,510	1,191	4%
Total	**28,042,902**	**8,804,736**	**2,717,900**	**41%**

3.3.2. Critical and Essential Habitat

California has the greatest number of Threatened and Endangered Species in the continental U.S., representing nearly every taxonomic group, from plants and invertebrates to birds, mammals, fish, amphibians, and reptiles (Wilcove et al. 1998). In an analysis that identified "irreplaceable" places for preventing species extinctions (Stein et al. 2000), three out of six of the most important areas in the United States are in California, including the South Coast Ecoregion, San Francisco Bay Area, and Death Valley (along with Hawaii, Southern Appalachians, and the Florida Panhandle). The California Floristic Province, which covers roughly 69% of the state, is one of 25 global hotspots of biodiversity, and the only one in North America (Mittermeier et al. 1998, Mittermeier et al. 1999). As a consequence of habitat conversion to urban and agricultural uses, many areas in the state have become hotspots for species at risk of extinction.

As of December 2, 2009, there were 308 federally listed species in California, including 129 animals and 179 plants (http://ecos.fws.gov). U.S. Fish and Wildlife Service has mapped essential habitat or designated Critical Habitat for 100 of these species, covering a total of 13.5 million acres in Critical Habitat and 1 million acres in essential habitat in California.

A total of 80% of the compiled essential and Critical Habitat was captured within the Essential Habitat Connectivity network of Natural Landscape Blocks (72%; 10.4 million ac) and Essential Connectivity Areas (9%; 1.2 million ac; Figure 3.11). The network captured 50% or more of Critical and or Essential Habitat for 67 of the 100 species, while only 11 species' Critical Habitat was not captured at all by the network (Table 3.11). Many of the species not captured are restricted to very small ranges that occur in highly fragmented urbanized areas, such as the Palos Verdes blue butterfly (*Glaucopsyche lygdamus palosverdensis*), Buena Vista Lake shrew (*Sorex ornatus relictus*), and Ventura Marsh milkvetch (*Astragalus pycnostachyus* var. *lanosissimus*). The network also didn't capture Critical Habitat for two fish, Bonytail chub (*Gila elegans*) and Tidewater goby (*Eucyclogobius newberryi*), which is not surprising given that the Essential Habitat Connectivity Map is focused on terrestrial connectivity.

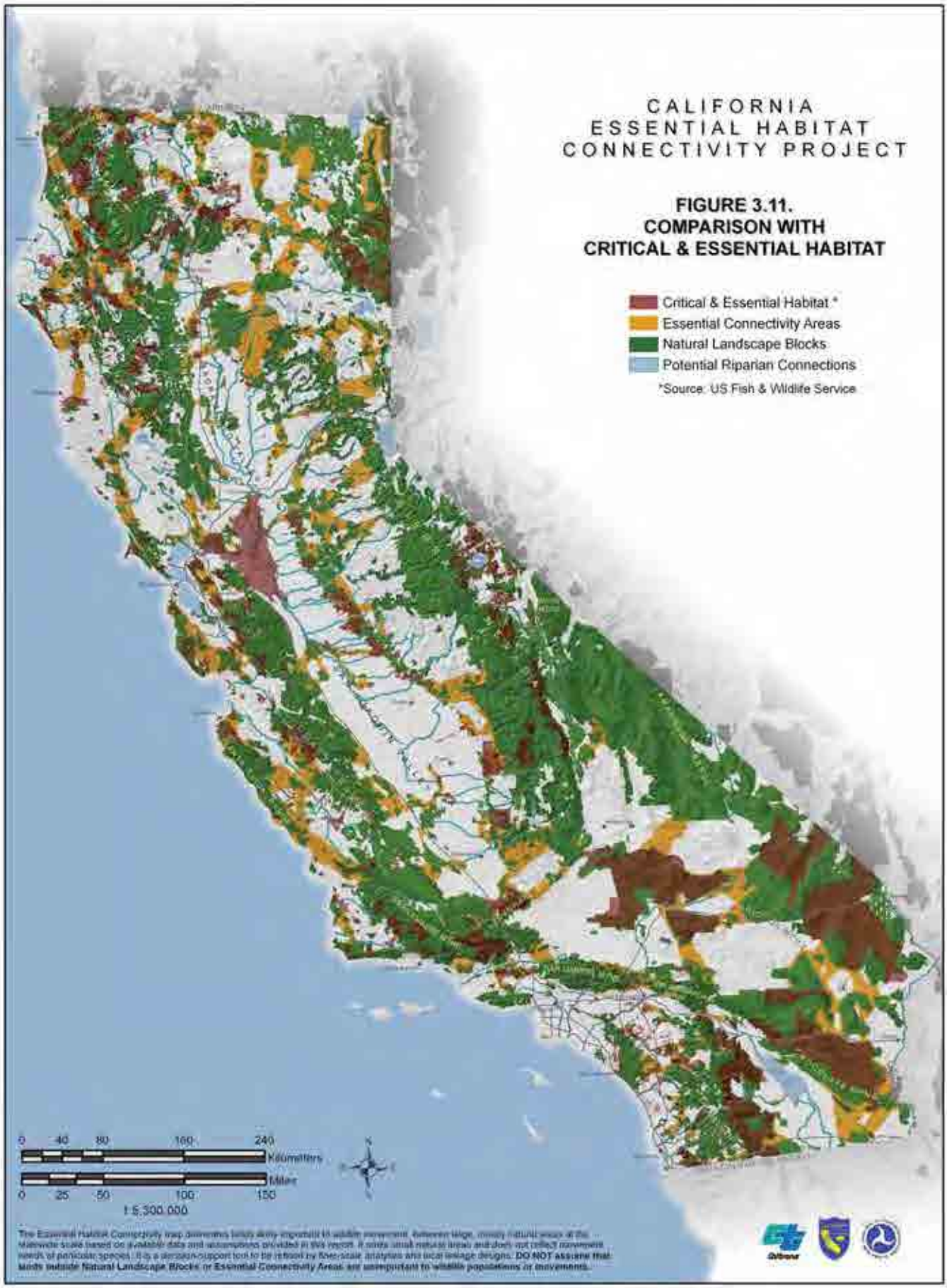

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.11.
COMPARISON WITH
CRITICAL & ESSENTIAL HABITAT
Critical & Essential Habitat.*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: US Fish & Wildlife Service
0 40 80 160 240
Kilometers
Miles
0 25 50 100 150
1:5,300,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement, between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analysis and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Table 3.11. Overlap between Essential Habitat Connectivity Map and Critical and essential habitat by species.[25]

Common Name (*Latin Name*)	Total Critical and or essential Habitat (acres)	Acres Critical or essential habitat in NLBs	Acres Critical or essential habitat in ECAs	Percent Critical or essential habitat covered by NLB or ECA
Amargosa Vole (*Microtus californicus scirpensis*)	4,487	4,180	0	93%
Buena Vista Lake Shrew (*Sorex ornatus relictus*)	84	0	0	0%
Fresno Kangaroo Rat (*Dipodomys nitratoides exilis*)	902	0	0	0%
Morro Bay Kangaroo Rat *(Dipodomys heermanni morroensis*)	680	526	0	77%
Peninsular Bighorn Sheep (*Ovis canadensis*)	817,240	767,598	16,996	96%
San Bernardino Kangaroo Rat (*Dipodomys merriami parvus*)	33,317	4,978	10,148	45%
Sierra Nevada Bighorn Sheep *(Ovis canadensis sierrae)*	417,769	412,980	0	99%
California Condor (*Gymnogyps californianus*)	605,171	451,262	81,080	88%
Coastal California Gnatcatcher (*Polioptila californica californica*)	372,667	110,675	58,710	45%
Greater Sage-Grouse (*Centrocercus urophasianus*)	904,283	752,351	9,085	84%
Inyo California towhee (*Pipilo crissalis eremophilus*)	2,169	1,186	0	55%
Least Bell's Vireo (*Vireo bellii pusillus*)	36,988	15,755	3,856	53%
Marbled Murrelet (*Brachyramphus marmoratus*)	741,392	429,204	127,133	75%
Northern Spotted Owl (*Strix occidentalis caurina*)	1,542,861	653,301	356,992	65%
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	17,212	3,936	2,185	36%
Western Snowy Plover (*Charadrius alexandrinus nivosus*)	7,272	961	2	13%
Alameda Whipsnake (*Masticophis lateralis euryxanthus*)	154,924	108,274	31,444	90%
Arroyo Toad (*Bufo californicus*)	104,720	56,035	9,808	63%
California Red-legged Frog (*Rana aurora draytonii*)	450,177	318,763	54,365	83%
California Tiger Salamander (*Ambystoma californiense*)	210,245	136,618	14,574	72%
Coachella Valley Fringe-toed Lizard (*Uma inornata*)	11,797	9,163	1,623	91%
Desert Tortoise (*Gopherus agassizii*)	4,761,055	4,499,136	103,172	97%
Mountain Yellow-legged Frog (*Rana muscosa*)	8,289	7,868	350	99%
Bonytail Chub (*Gila elegans*)	9,419	0	0	0%

[25] Acres reflect Final Critical Habitat for most species, both essential and Final Critical Habitat for nine species (arroyo toad, tidewater goby, San Diego fairy shrimp, California taraxacum, San Bernardino bluegrass, San Diego thornmint, Santa Ana sucker, spreading navarretia, and thread-leaved brodiaea) and essential habitat for two species (Vail Lake ceanothus and greater sage-grouse).

Delta Smelt (*Hypomesus transpacificus*)	819,293	104,756	45,118	18%
Desert Pupfish (*Cyprinodon macularius*)	770	527	0	68%
Little Kern Golden Trout (*Oncorhynchus aguabonita whitei*)	82,334	82,309	25	100%
Owens Tui Chub (*Gila bicolor snyderi*)	115	89	0	78%
Razorback Sucker (*Xyrauchen texanus*)	5,720	156	300	8%
Santa Ana Sucker (*Catostomus santaanae*)	23,736	10,615	555	47%
Tidewater Goby (*Eucyclogobius newberryi*)	1,589	20	0	1%
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	23,923	6,7766	15,370	93%
Conservancy fairy shrimp (*Branchinecta conservatio*)	161,627	121,653	14,548	84%
Delta green ground beetle (*Elaphrus viridis*)	1,077	743	0	69%
Laguna Mountains Skipper (*Pyrgus ruralis lagunae*)	6,259	4,035	395	71%
Longhorn fairy shrimp (*Branchinecta longiantenna*)	13,547	4,432	58	33%
Morro shoulderband snail (*Helminthoglypta walkeriana*)	2,566	1,149	124	50%
Palos Verdes blue butterfly (*Glaucopsyche lygdamus palosverdensis*)	91	0	0	0%
Quino checkerspot butterfly (*Euphydryas editha quino*)	171,764	89,779	17,991	63%
Riverside fairy shrimp (*Streptocephalus woottoni*)	307	39	232	88%
San Diego fairy shrimp (*Branchinecta sandiegonensis*)	13,146	6,020	200	47%
Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)	515	460	0	89%
Vernal pool fairy shrimp (*Branchinecta lynchi*)	590,004	336,494	81,075	71%
Vernal pool tadpole shrimp (*Lepidurus packardi*)	228,783	145,684	39,011	81%
Zayante band-winged grasshopper (*Trimerotropis infantilis*)	11,140	1,462	8,176	87%
Amargosa niterwort (*Nitrophila mohavensis*)	1216	0	0	0%
Antioch Dunes evening primrose (*Oenothera deltoides* ssp. *Howellii*)	305	0	0	0%
Ash Meadows gumplant (*Grindelia fraxinopratensis*)	295	0	0	0%
Ash-gray indian paintbrush (*Castilleja cinerea*)	1,768	803	487.57	73%
Baker's larkspur (*Delphinium bakeri*)	1,831	881	797.46	92%
Bear valley sandwort (*Arenaria ursina*)	1,412	471	465.03	66%
Braunton's milk-vetch (*Astragalus brauntonii*)	3,299	2,548	458.63	91%
Butte County meadowfoam (*Limnanthes floccosa* ssp. *Californica*)	16,644	7,251	238.55	45%
California taraxacum (*Taraxacum californicum*)	1,956	541	459.25	51%
Colusa grass (*Neostapfia colusana*)	152,033	114,989	16,873.63	87%
Contra costa goldfields (*Lasthenia conjugens*)	14,739	4,083	1,579.05	38%
Contra costa wallflower (*Erysimum capitatum* var. *angustatum*)	305	0	0	0%
Cushenbury buckwheat (*Eriogonum ovalifolium* var. *vineum*)	6,959	4,858	1,086	85%

Cushenbury milk-vetch (*Astragalus albens*)	4,370	3,411	787	96%
Cushenbury oxytheca (*Oxytheca parishii* var. *goodmaniana*)	3,153	2,315	283	82%
Fish slough milk-vetch (*Astragalus lentiginosus* var. *piscinensis*)	8,084	7,849	0	97%
Fleshy owl's-clover (*Castilleja campestris* ssp. *succulenta*)	175,745	122,399	11,557	76%
Gaviota tarplant (*Deinandra increscens* ssp. *Villosa*)	9,679	7,363	0	76%
Greene's tuctoria (*Tuctoria greenei*)	145,051	106,152	16,176	84%
Hairy orcutt grass (*Orcuttia pilosa*)	79,557	56,031	3,525	75%
Hoover's spurge (*Chamaesyce hooveri*)	114,637	79,422	22,859	89%
Keck's checker-mallow (*Sidalcea keckii*)	1,081	704	16	67%
Kneeland Prairie penny-cress (*Thlaspi californicum*)	74	0	0	0%
La Graciosa thistle (*Cirsium loncholepis*)	41,070	8,947	0	22%
Large-flowered fiddleneck (*Amsinckia grandiflora*)	160	152	0	95%
Lompoc yerba santa (*Eriodictyon capitatum*)	6,397	4,063	0	64%
Lyon's pentachaeta (*Pentachaeta lyonii*)	3,579	2,492	471	83%
Mexican flannelbush (*Fremontodendron mexicanum*)	228	228	0	100%
Monterey spineflower (*Chorizanthe pungens* var. *pungens*)	18,949	2,410	7,122	50%
Munz's onion (*Allium munzii*)	1,245	648	17	53%
Nevin's Barberry (*Berberis nevinii*)	5	5	0	100%
Otay tarplant (*Deinandra conjugens*)	6,333	2,870	0	45%
Parish's daisy (*Erigeron parishii*)	4,424	2,744	1,108	87%
Peirson's milk-vetch (*Astragalus magdelanae* var. *peirsonii*)	21,864	21,193	543	99%
Purple amole (*Chlorogalum purpureum*)	1,530	0	758	50%
Robust spineflower (*Chorizanthe robusta* var. *robusta*)	469	157	11	36%
Sacramento orcutt grass (*Orcuttia viscida*)	33,277	29,549	1,611	94%
San Bernadino Mountains bladderpod (*Lesquerella kingii* ssp. *Bernardina*)	1,026	478	0	47%
San Bernardino bluegrass (*Poa atropurpurea*)	2,531	979	397	54%
San Diego thornmint (*Acanthomintha ilicifolia*)	1,749	800	310	63%
San Joaquin orcutt grass (*Orcuttia inaequalis*)	136,188	76,686	17,518	69%
Santa Cruz tarplant (*Holocarpha macradenia*)	2,902	295	70	13%
Scott's Valley polygonum (*Polygonum hickmanii*)	288	0	288	100%
Slender orcutt grass (*Orcuttia tenuis*)	94,265	49,274	15,728	69%
Soft-bird's beak (*Cordylanthus mollis* ssp. *mollis*)	2,292	1,384	703	91%
Solano grass (*Tuctoria mucronata*)	440	0	0	0%
Southern mountain wild buckwheat (*Eriogonum kennedyi* var. *austromontanum*)	903	130	319	50%
Spreading navarretia (*Navarretia fossalis*)	14,273	3,036	2,864	41%
Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*)	2,120	1,662	454	99.8%
Thread-leaved brodiaea (*Brodiaea filifolia*)	6,403	3,537	193	58%

Vail Lake ceanothus (*Ceanothus ophiochilus*)	198	198	0	100%
Ventura marsh milk-vetch (*Astragalus pycnostachyus* var. *lanosissimus*)	426	0	0	0%
Willowy monardella (*Monardella linoides* ssp. *viminea*)	73	0	73	100%
Yadon's piperia (*Piperia yadonii*)	2,169	191	215	19%
Yellow larkspur (*Delphinium luteum*)	2,521	750	1,673	96%

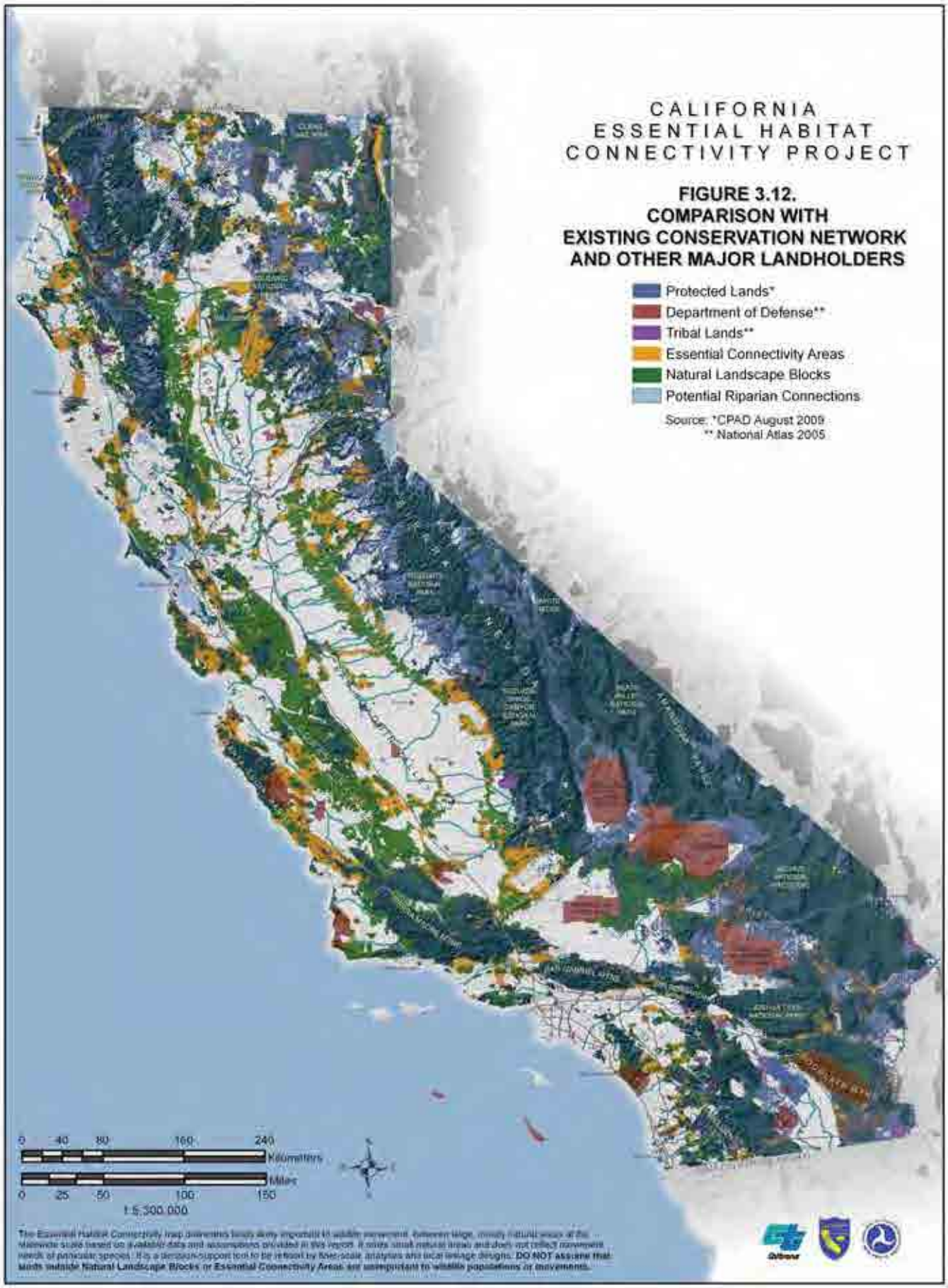
3.3.3. Existing Conservation Network and other Major Landholders

Significant conservation investments have been made throughout the State of California. As of August 27, 2009, the California Protected Areas Database included 48.7 million acres of protected lands in fee ownership by public agencies and non-profits in the state held (GreenInfo Network 2009a). Other major lands contributing in varying degrees to the state's conservation network include 4.1 million acres administered by the Department of Defense and 0.7 million acres owned by Native American tribes.

Roughly 76% of the protected lands in the California Protected Areas Database were captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (67% or 32.6 million acres) and Essential Connectivity Areas (9% or 4.5 million acres; Table 3.12 and Figure 3.12). The network captured almost all (99.6%) National Park Service lands, 91% of conservation lands administered by non-governmental organizations, 80% of California Department of Parks and Recreation lands, and 80% of various county lands. The network also captured 31% of lands administered by the Department of Defense and 34% of land owned by Native American tribes (Table 3.12).

Table 3.12. Overlap between Essential Habitat Connectivity Map and ownership of various land management agencies.

Land Management Agency	Total Acres	Overlap by Network (acres)	Percent
US Forest Service	20,503,618	14,965,074	73%
US Bureau of Land Management	15,031,297	10,640,318	71%
National Park Service	7,487,770	7,456,417	99.6%
California Department of Parks and Recreation	1,444,053	1,239,620	86%
US Fish and Wildlife Service	332,841	218,182	66%
California Department of Fish and Game	624,826	435,594	70%
US Bureau of Reclamation	176,301	26,742	15%
US Army Corps of Engineers	47,404	20,858	44%
Non Governmental Organization	577,942	523,423	91%
Other Federal	8,847	5,811	66%
Other State	854,550	541,537	63%
Special District	553,778	330,071	60%
City	692,581	496,730	72%
County	309,300	248,284	80%
Unknown	4,815	1,793	37%
Totals	**48,649,923**	**37,150,455**	**76%**


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.12.
COMPARISON WITH
EXISTING CONSERVATION NETWORK
AND OTHER MAJOR LANDHOLDERS
Protected Lands*
Department of Defense**
Tribal Lands**
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
Source: *CPAD August 2009
** National Atlas 2005
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000

3.3.4. 2001 California Missing Linkages Project

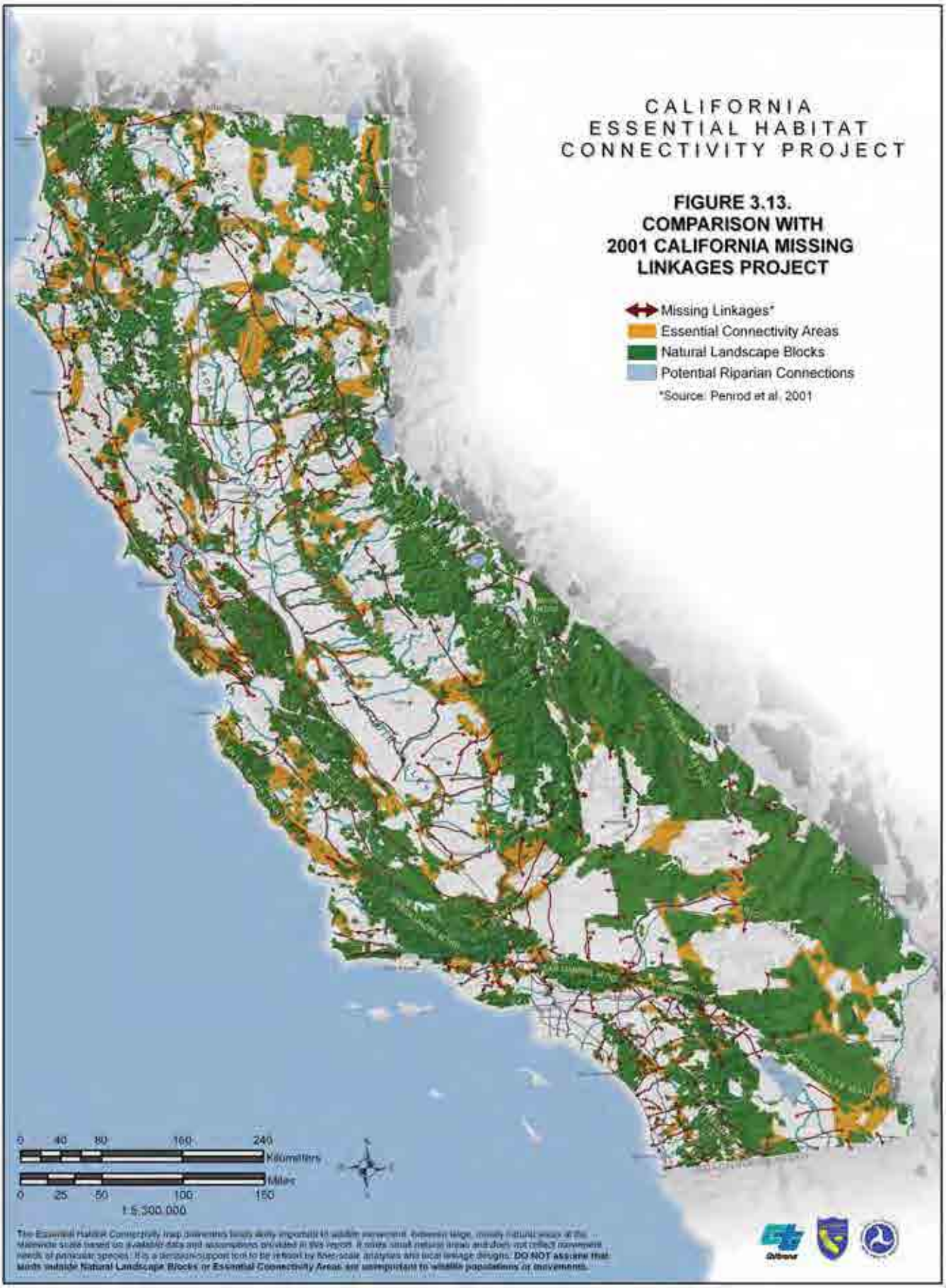
In 2000, the California-wide Missing Linkages Conference brought together land managers and planners, conservationists, and scientists from each ecoregion in the state to identify the location of, and threats to, the most important movement corridors for California's wildlife (Penrod et al. 2001). This one-day forum included breakout sessions by ecoregion where participants shared their knowledge by marking the locations of important movement corridors throughout the state on ecoregional maps. Over 160 scientists, conservationists, land managers, and planners identified 232 linkages, each represented by a placeholder arrow.

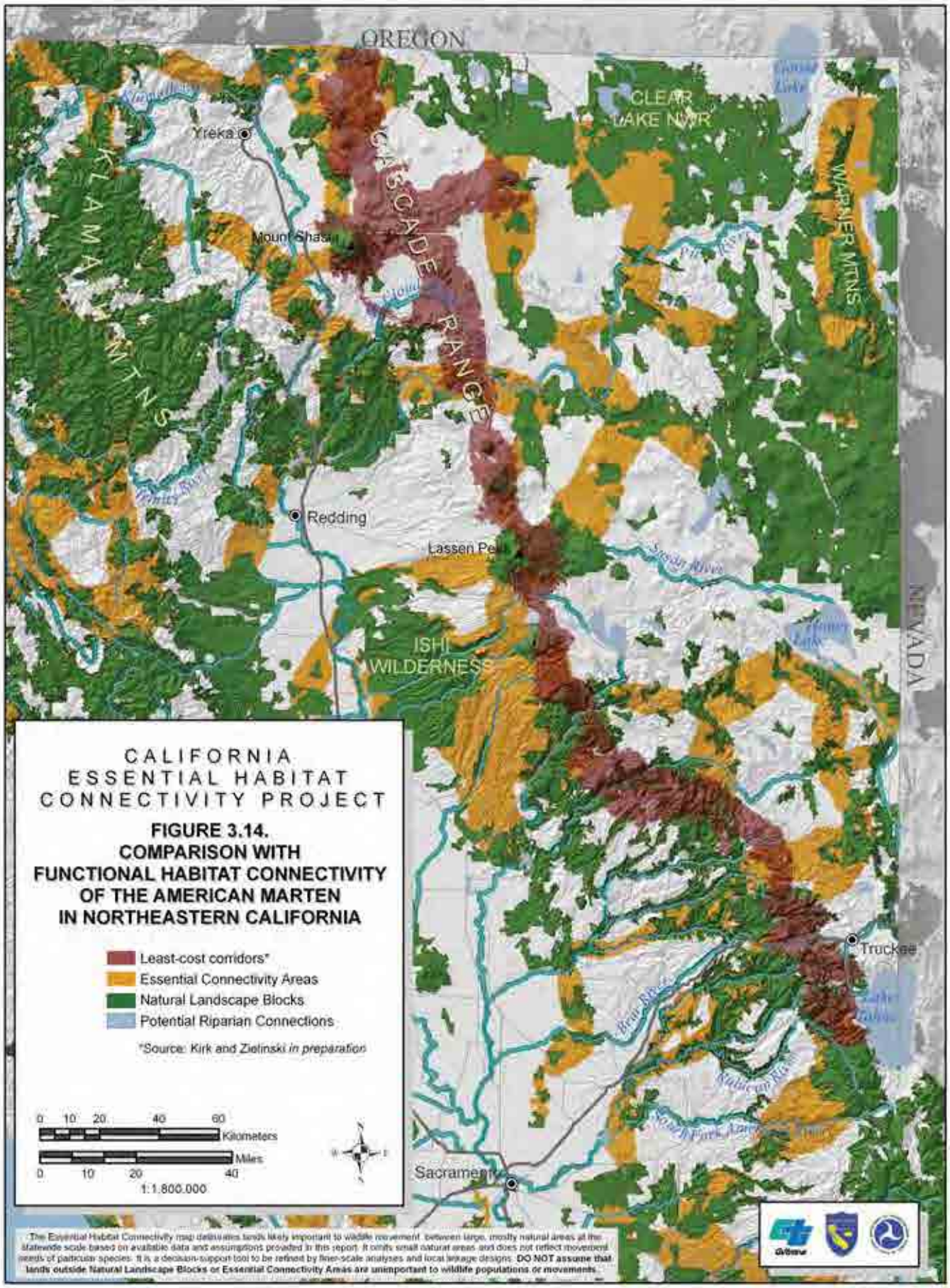
Many of the statewide Missing Linkages arrows were not captured by the Essential Habitat Connectivity Map (Figure 3.13). Most of the arrows were drawn between protected areas, which do not necessarily correspond with Natural Landscape Blocks based on ecological condition and other biological modifiers. Many other arrows were drawn across transportation barriers and are addressed as Road Fragmentations rather than Essential Connectivity Areas. In addition, several of the arrows are truly "Missing Linkages" where extensive restoration would be needed to re-establish connectivity function.

3.3.5. Functional Habitat Connectivity of the American Marten in Northeastern California

Kirk and Zielinski (in preparation) evaluated habitat connectivity for the American marten (*Martes americana*) by assessing the structural and functional aspects of the landscape as they affect marten movements within a typical home range and potential dispersal distances of juvenile martens. Structural connectivity was evaluated using a regional-scale GIS model of reproductive habitat (Kirk 2007). Functional connectivity was assessed using least-cost corridor modeling between seven targeted endpoints known to serve as core habitat for the marten. The analyses produced six least-cost corridors which serve to sequentially connect from the Oregon border to Mt. Shasta Wilderness, to Thousand Lakes Wilderness, to Lassen National Park Wilderness, to Bucks Lake Wilderness, to Lakes Basin Plumas National Forest, to Desolation Wilderness. The six least-cost corridors were delineated for marten using the top 25% permeability slice.

Approximately 53% of the total area delineated by the least-cost corridors for marten (Kirk and Zielinski *in preparation*) was captured by the California Essential Habitat Connectivity Project's network of Natural Landscape Blocks (29% or 471,232 acres) and Essential Connectivity Areas (23% or 375,798 acres; Figure 3.14). The network captured 50% or more of four of the six least-cost corridors delineated for marten (Table 3.13). While the Essential Connectivity Map captured all of the targeted Wilderness Areas in Natural Landscape Blocks and the majority of least-cost corridors south of the Thousand Lakes Wilderness, the least-cost corridor between Mt. Shasta Wilderness and Thousand Lakes Wilderness was not well addressed by the network. This is likely due to the long span of Shasta National Forest crossed by the marten linkage that lacks large protected areas that would qualify as Natural Landscape Blocks. In addition, because the marten prefers dense, higher-elevation forests, the species-based model is biased toward least-cost corridors following or connecting higher elevation ridges and peaks, whereas our least-cost corridors tend to follow the shortest routes having natural landcover, regardless of elevation or the type


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.13.
COMPARISON WITH
2001 CALIFORNIA MISSING
LINKAGES PROJECT
Missing Linkages*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: Penrod et al. 2001
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000
The Essential Habitat Connectivity map delineates locally likely important wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analysis and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.


OREGON
CLEAR LAKE NWR
Yreka
CASCADE RANGE
KLAMATH MTNS
Mount Shasta
WARNER MTNS
Redding
Lassen Peak
ISHI WILDERNESS
NEVADA
Truckee
Sacramento
CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT
FIGURE 3.14. COMPARISON WITH FUNCTIONAL HABITAT CONNECTIVITY OF THE AMERICAN MARTEN IN NORTHEASTERN CALIFORNIA
Least-cost corridors*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: Kirk and Zielinski in preparation
0 10 20 40 60
Kilometers
Miles
0 10 20 40
1:1,800,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

of natural landcover. Hence our Essential Connectivity Network likely includes more shrubland and woodland communities at lower elevation, on average, than would be selected by martens.

Table 3.13. Overlap between Essential Habitat Connectivity Map and American marten connectivity areas in northeastern California (Kirk and Zielinski, in preparation).

Marten Connections	Marten LCC (acres)	NLB Overlap (acres)	ECA Overlap (acres)	Network Overlap (acres)	Percent
Oregon Border - Mt. Shasta Wilderness	439,442	46,655	153,991	200,646	46%
Mt. Shasta Wilderness - Thousand Lakes Wilderness	385,734	58,844	52,115	110,960	29%
Thousand Lakes Wilderness - Lassen Natl. Park Wilderness	86,794	49,584	18,261	67,844	78%
Lassen Natl. Park Wilderness - Bucks Lake Wilderness	146,777	56,841	57,883	114,724	78%
Bucks Lake Wilderness - Lakes Basin Plumas Natl. Forest	333,910	140,155	68,010	208,165	62%
Lakes Basin Plumas Natl. Forest - Desolation Wilderness	207,631	119,154	25,538	144,691	70%
Total	**1,600,290**	**471,232**	**375,798**	**847,030**	**53%**

3.3.6. Wildlands Conservation in the Central Coast Region of California

The Guide to Conservation for the Central Coast Region of California (Thorne et al. 2002) presents a network of core habitat areas and habitat linkages that were developed based on the needs of three mammal focal species: mountain lion (*Puma concolor*), San Joaquin kit fox (*Vulpes macrotis mutica*), and pronghorn antelope (*Antilocapra americana*). This network forms the connective terrestrial backbone of the Wildlands Conservation Plan for the Central Coast Ecoregion (Thorne et al. 2002), while aquatic habitat needs were addressed by identifying strategies for long-term restoration of steelhead trout (*Oncorhynchus mykiss*) populations.

The framework for developing the Wildlands Conservation Plan is based on the preferred habitat of the four focal species and involved three major steps (Thorne et al. 2002): (1) delineate a conservation network based on the habitat and spatial requirements for the three mammal species, which together use a majority of habitat types in the region; (2) assess how the resulting Mammal Network overlaps with the target areas identified for the conservation and restoration of steelhead habitat; and (3) conduct representation analyses to evaluate how well the Mammal Network captures elements of biodiversity in the region, including oaks, important bird habitats, The Nature Conservancy portfolio sites, serpentine geology, old-growth redwoods, and California red-legged frog (*Rana aurora draytonii*) and tiger salamander (*Ambystoma tigrinum*) populations.

The resulting network identified roughly 68% (5.4 million acres) of the region as potential core habitat areas and habitat linkages that should be further evaluated for their conservation value (Thorne et al. 2002). The targeted biodiversity elements were well-represented in the proposed network: oak communities (75-92% for five species), The Nature Conservancy portfolio sites (73%), serpentine rock (82%), old-growth redwoods (91%), coastal sage/chaparral (92%), and non-native grasslands (77%), red-legged frogs (50%) and California tiger salamanders (53%).

Roughly 84% of the Central Coast Network (Thorne et al. 2002) was captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (70% or 3.8 million ac) and Essential Connectivity Areas (14% or 747,603 ac; Figure 3.15). However, a few of the habitat linkages identified by Thorne et al. (2002) were not captured, which emphasizes the need for focal-species analyses (see Chapter 5). Key connections that were not captured by the network include the Santa Cruz Mountains to the Gabilan Range and connections to the Santa Lucia Range through the Salinas Valley.

3.3.7. A Potential Regional Conservation Network for the Central Valley Ecoregion

Huber et al. (2010) developed a potential regional conservation network for the Central Valley using the MARXAN reserve selection algorithm and least-cost corridor analysis. Conservation targets used to develop the network included seven focal species and one ecological community: tule elk (*Cervus elaphus nannodes*), pronghorn antelope, bobcat (*Lynx rufus*), San Joaquin kit fox, giant garter snake (*Thamnophis gigas*), western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), and Swainson's hawk (*Buteo swainsoni*), and vernal pool community complexes (Huber 2008). In order to assemble a conservation network in this region, where the remaining natural areas are primarily small and highly fragmented remnants surrounded by an agricultural matrix, significant habitat restoration will be necessary. Therefore, in addition to habitat suitability indices based on existing conditions, they also considered the context and "restorability" of human-converted planning units. Connectivity analyses were then conducted individually for each of the five mobile terrestrial focal species only between the cores that were selected for that species.

This regional analysis identified 52 core reserves (i.e., conservation opportunity areas) ranging in size from 5,152 acres to 291,000 acres, and covered 12% (1.8 million acres) of the total land area of the ecoregion. Least-cost corridor analyses delineated 388 species-specific corridors linking the core areas (bobcat = 120, giant garter snake = 27, kit fox = 50, tule elk = 121), covering 18% (4.1 million ac) of the ecoregion. Approximately 63% of the combined core reserves and corridors delineated for the Central Valley (Huber et al. 2010) were captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (46% or 2.7 million ac) and Essential Connectivity Areas (17% or 1.0 million ac; Figure 3.16; Table 3.14). While there was good overlap with the core reserves and Natural Landscape Blocks, fewer of the corridors were captured by the Essential Connectivity Areas, which is likely due to the approach that Huber et al. (2010) took for looking at future restoration opportunities rather than just existing conditions.

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.15.
COMPARISON WITH
WILDLANDS CONSERVATION
IN THE CENTRAL COAST REGION
OF CALIFORNIA
Central Coast Network*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: Thorne et al. 2002
San Francisco
Stockton
Monterey
Fresno
Tulare
Bakersfield
Santa Barbara
SANTA CRUZ MTNS
DIABLO RANGE
SAN JOAQUIN VALLEY
SALINAS VALLEY
COAST RANGES
SANTA LUCIA RANGE
TEHACHAPI RANGE
SIERRA MADRE MTNS
SANTA INEZ MTNS
0 15 30 60 90
Kilometers
0 10 20 40 60
Miles
1:2,100,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

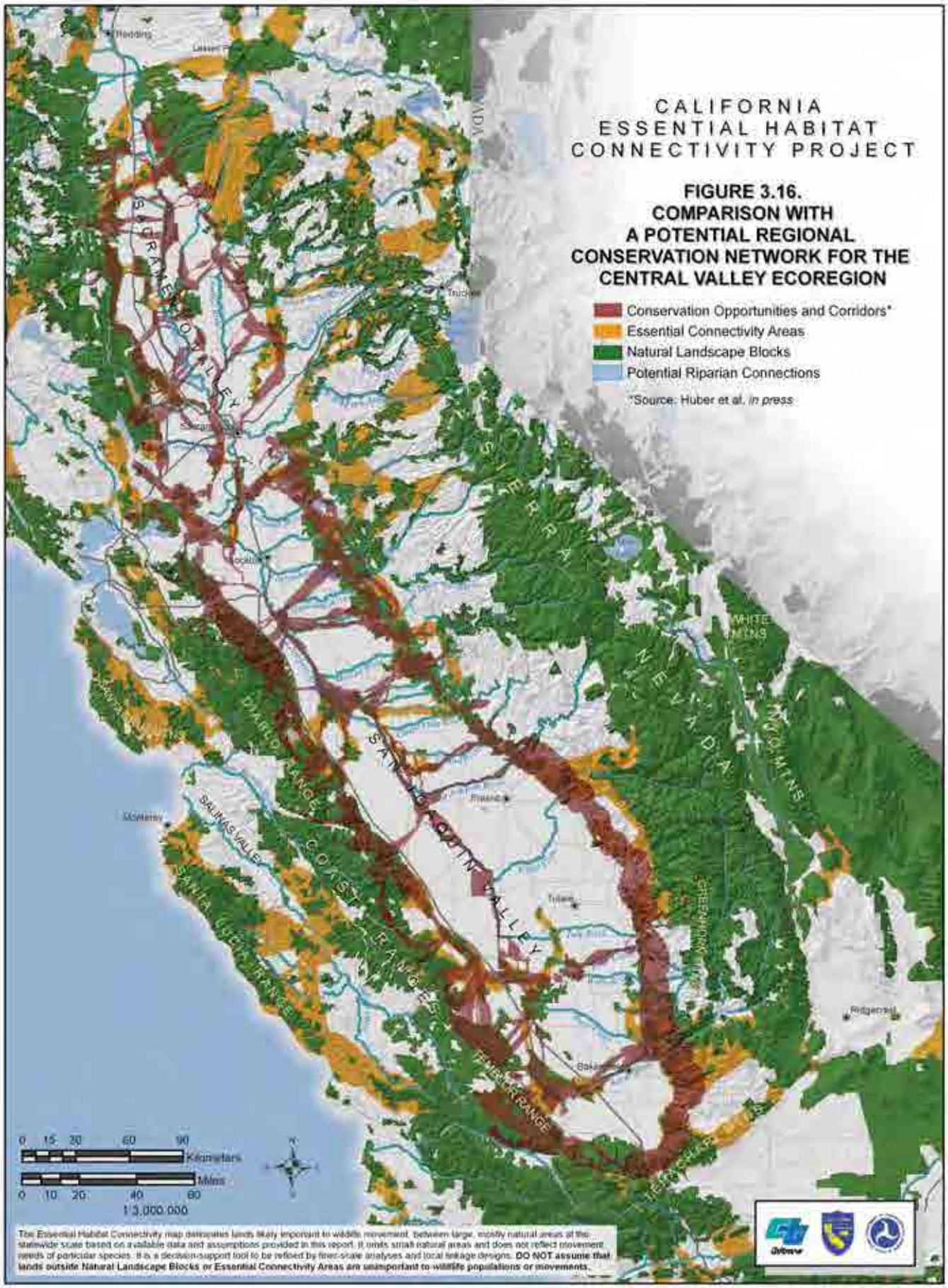

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.16.
COMPARISON WITH
A POTENTIAL REGIONAL
CONSERVATION NETWORK FOR THE
CENTRAL VALLEY ECOREGION
Conservation Opportunities and Corridors*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: Huber et al. in press
Redding
Lassen
Truckee
Sacramento
Stockton
Monterey
Fresno
Tulare
Bakersfield
Ridgecrest
SACRAMENTO VALLEY
SIERRA NEVADA
WHITE MTNS
INYO MTNS
DIABLO RANGE
SAN JOAQUIN VALLEY
SALINAS VALLEY
COAST RANGES
SANTA LUCIA RANGE
TEHACHAPI RANGE
GREENHORN MTNS
0 15 30 60 90
Kilometers
Miles
0 10 20 40 60
1:3,000,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement, between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Table 3.14. Overlap between Essential Habitat Connectivity Map and a Potential Regional Conservation Network for the Central Valley Ecoregion (Huber et al. 2010).

Comparison Description	Total Overlap (acres)	Percent	Overlap with Corridors (acres)	Percent	Overlap with Conservation Opportunities	Percent
Corridors and Opportunities Overlap with NLB	2,730,665	46%	1,635,436	28%	1,095,230	19%
Corridors and Opportunities Overlap with ECA	1,001,369	17%	807,763	14%	193,606	3%
Corridors and Opportunities Overlap with Network	**3,732,034**	**63%**	**2,443,198**	**42%**	**1,288,836**	**22%**

3.3.8. South Coast Missing Linkages Project

South Coast Missing Linkages has prioritized and designed landscape linkages that are widely considered the backbone of a conservation strategy for southern California (Beier et al. 2006). The linkages cover 2.1 million acres and stitch together over 18 million acres of existing conservation investments (national forests, state and national parks, etc.) to form the South Coast Wildland Network, maintaining connected wildlife populations from the southern Sierra Nevada to Baja California, and from the beaches of Camp Pendleton eastward to the deserts of Anza-Borrego Desert State Park.

Eleven focal species-based Linkage Designs were developed to form the South Coast Wildland Network (Beier et al. 2006, Luke et al. 2004, Penrod et al. 2003, 2004a, 2004b, 2005a, 2005b, 2005c, 2006a, 2006b, 2006c, 2006d; http://scwildlands.org/reports/). The number of focal species for each linkage ranged from 14 to 34. Least-cost corridor analyses and patch configuration analyses (Chapter 5) were conducted to develop a linkage design that served all species.

Roughly 81% of the combined South Coast Missing Linkage Designs were captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (55% or 1.1 million ac) and Essential Connectivity Areas (26% or 533,250 ac; Figure 3.17; Table 3.15). The Essential Connectivity Map captured the majority of all Linkage Designs identified by the South Coast Missing Linkages effort, except two. The western branch of the San Bernardino – Granite Connection was not included largely due to the stringent criteria used to define Natural Landscape Blocks in the Mojave Ecoregion. In the San Bernardino-San Jacinto Connection, only the eastern-most branches of the Linkage Design were captured by the network. This is largely due to the fact that the least-cost corridors for the Essential Habitat Connectivity Map were run between centroids within the targeted Natural Landscape Blocks, while the South Coast Missing Linkages effort conducted Least Cost Corridor analyses for three focal species (mountain lion, American badger, and mule deer) using potential breeding habitat within the San Bernardino National Forest and small protected lands in the Badlands area, south of the San Bernardino Mountains, as the targeted endpoints for the analyses.

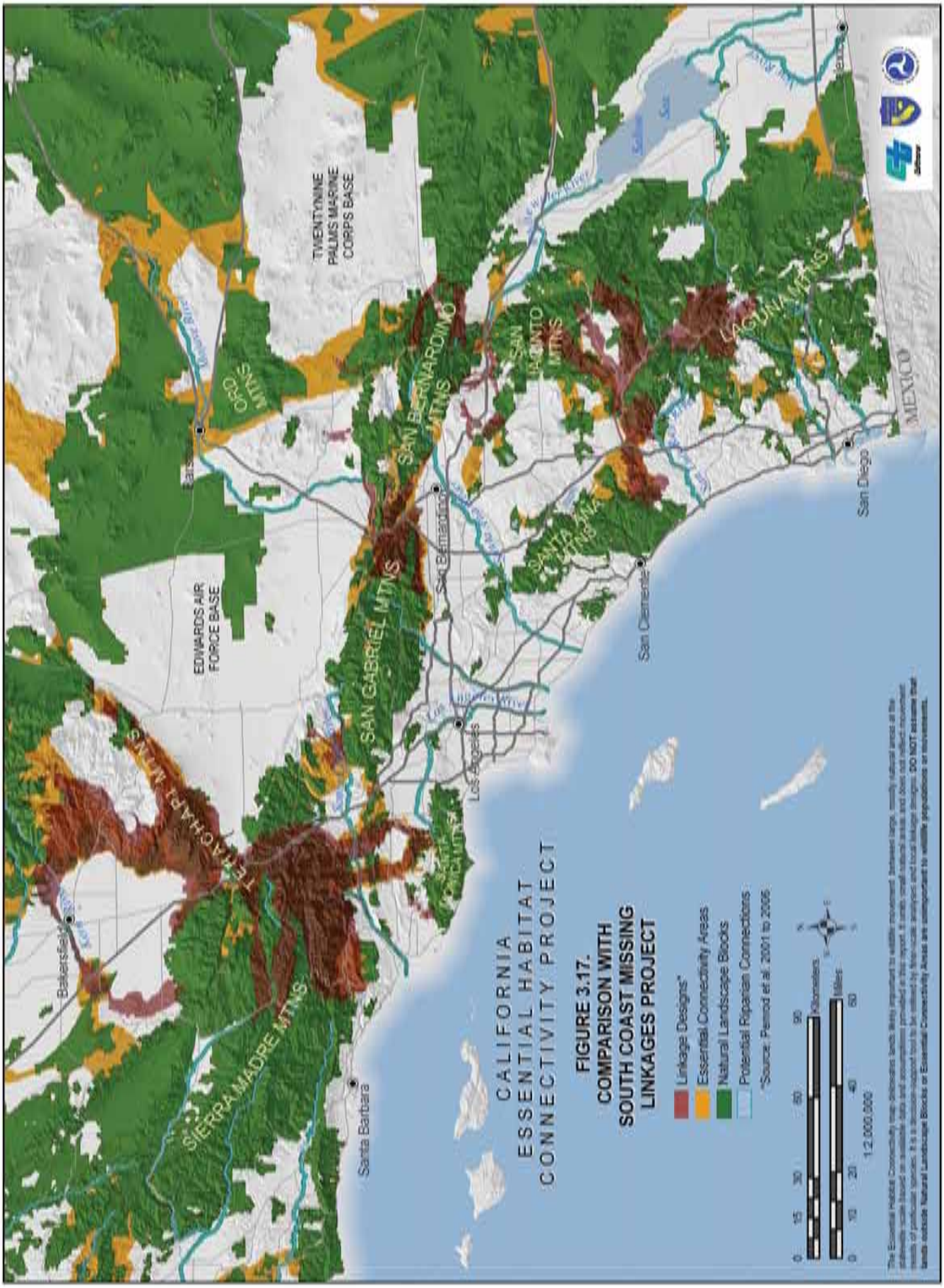

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.17.
COMPARISON WITH
SOUTH COAST MISSING
LINKAGES PROJECT
Linkage Designs*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: Penrod et al. 2001 to 2006
Kilometers
Miles
1:2,000,000
Bakersfield
Santa Barbara
Los Angeles
San Bernardino
San Clemente
San Diego
Barstow
EDWARDS AIR
FORCE BASE
TWENTYNINE
PALMS MARINE
CORPS BASE
ORO
MTNS
SIERRA MADRE MTNS
TEHACHAPI MTNS
SAN GABRIEL MTNS
SAN BERNARDINO
MTNS
SAN
JACINTO
MTNS
SANTA
ANA
MTNS
LAGUNA MTNS
MEXICO

Table 3.15. Overlap between Essential Habitat Connectivity Map and Linkage Designs from the South Coast Missing Linkages Project.

Linkage Design	Total Acres	Overlap by NLB (acres)	Overlap by ECA (acres)	Overlap by Network (acres)	Percent Overlap
Tehachapi	661,127	233,222	280,957	514,179	78%
Sierra Madre-Castaic	537,534	431,768	72,383	504,151	94%
Santa Monica-Sierra Madre	112,943	40,752	39,199	79,951	71%
San Gabriel-Castaic	24,571	296	19,348	19,644	80%
San Gabriel-San Bernardino	135,145	79,534	45,987	125,522	93%
San Bernardino - Granite	11,946	3,228	2,306	5,534	46%
San Bernardino-Little San Bernardino	62,069	47,681	4,097	51,777	83%
San Bernardino-San Jacinto	53,532	16,178	6,174	22,352	42%
Palomar-San Jacinto/Santa Rosa	208,753	128,456	25,776	154,232	74%
Santa Ana-Palomar	105,176	53,238	37,024	90,262	86%
Peninsular-Borrego	150,735	101,152	0	101,152	67%
Totals	**2,063,532**	**1,135,505**	**533,250**	**1,668,755**	**81%**

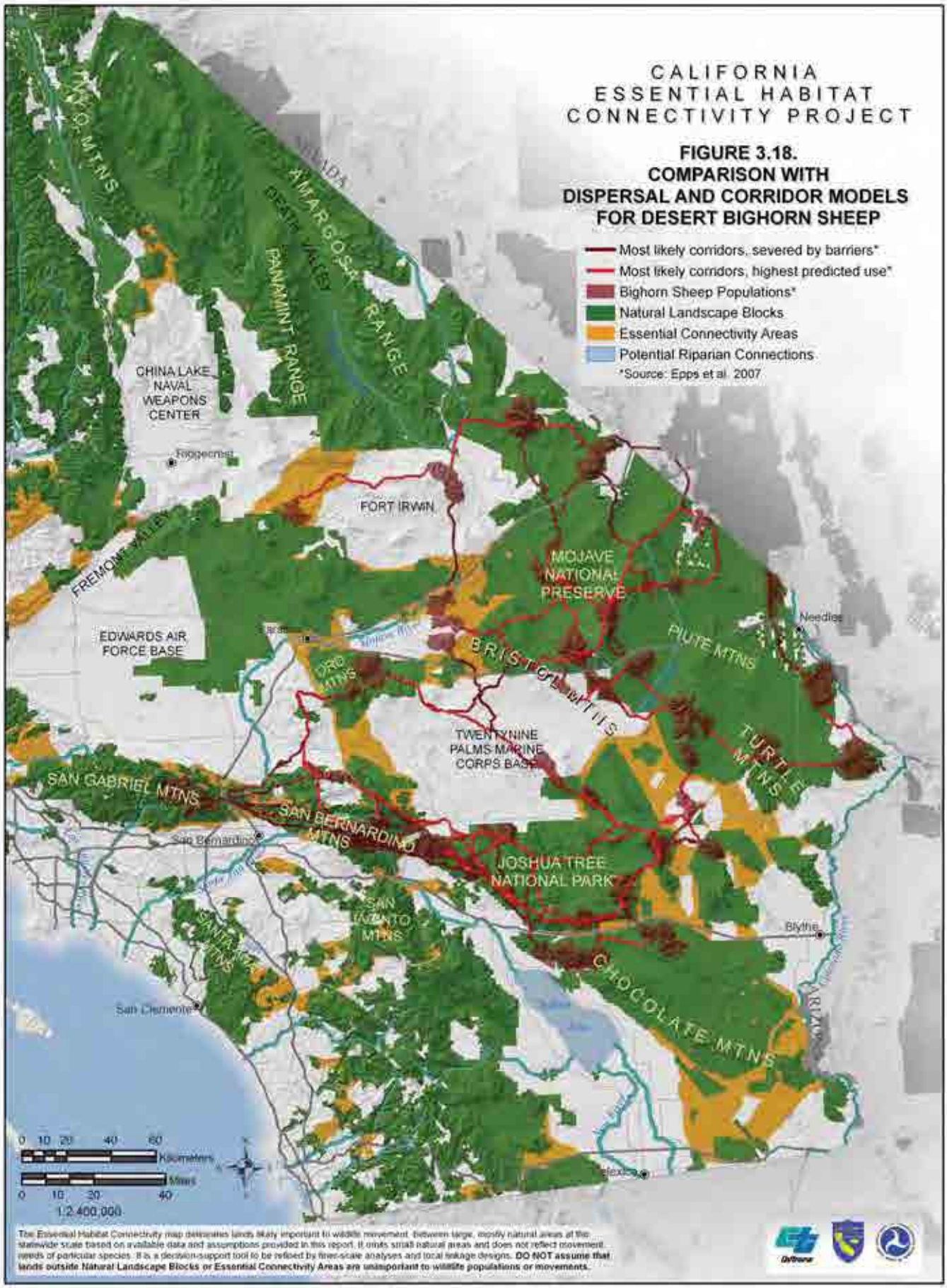
3.3.9. Dispersal and Corridor Models for Desert Bighorn Sheep

Epps et al. (2007) used spatially explicit, high-resolution genetic data to infer variation in movements of desert bighorn sheep (*Ovis canadensis nelsoni*) in portions of the Mojave and Sonoran Desert ecoregions to examine the impact of terrain and roads on movement and predict possible movement corridors. Least-cost path models estimated effective geographical distances among 26 populations.

Approximately 86% of the population polygons delineated for desert bighorn sheep (Epps et al. 2007) were captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (82% or 1.2 million ac) and Essential Connectivity Areas (4% or 59,490 ac; Figure 3.18). Roughly 86% (7,363 km; 4,575 mi) of the most likely paths with the highest predicted use were captured by the statewide network and 85% (3,537 km; 2,198 mi) of the most likely paths severed by barriers were captured. One notable omission is an Essential Connectivity Area between Joshua Tree National Park and the Newberry-Rodman Area of Critical Environmental Concern that links the Sheephole, Bullion, and Bristol Mountains, which Epps et al. (2007) identified as a most likely corridor, highest predicted use.

3.3.10. California Desert Connectivity Project

The goal of this ongoing project is to identify areas where maintaining or restoring ecological connectivity is essential to conserving biological diversity within California deserts in the face of human land-uses and climate change (www.scwildlands.org). This recently initiated effort is conducting a comprehensive connectivity assessment to identify wildland blocks of high ecological integrity, and key habitat connectivity areas between them and to adjacent


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.18.
COMPARISON WITH
DISPERSAL AND CORRIDOR MODELS
FOR DESERT BIGHORN SHEEP
Most likely corridors, severed by barriers*
Most likely corridors, highest predicted use*
Bighorn Sheep Populations*
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
*Source: Epps et al. 2007
CHINA LAKE NAVAL WEAPONS CENTER
Ridgecrest
FORT IRWIN
MOJAVE NATIONAL PRESERVE
EDWARDS AIR FORCE BASE
Barstow
Needles
PLUTE MTNS
BRISTOL MTNS
TWENTYNINE PALMS MARINE CORPS BASE
TURTLE MTNS
SAN GABRIEL MTNS
SAN BERNARDINO MTNS
San Bernardino
JOSHUA TREE NATIONAL PARK
SAN JACINTO MTNS
SANTA ANA MTNS
Blythe
CHOCOLATE MTNS
San Clemente
0 10 20 40 60
Kilometers
Miles
0 10 20 40
1:2,400,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

ecoregions. The project is using similar methods as those used for the South Coast Missing Linkages effort (Section 3.3.8.).

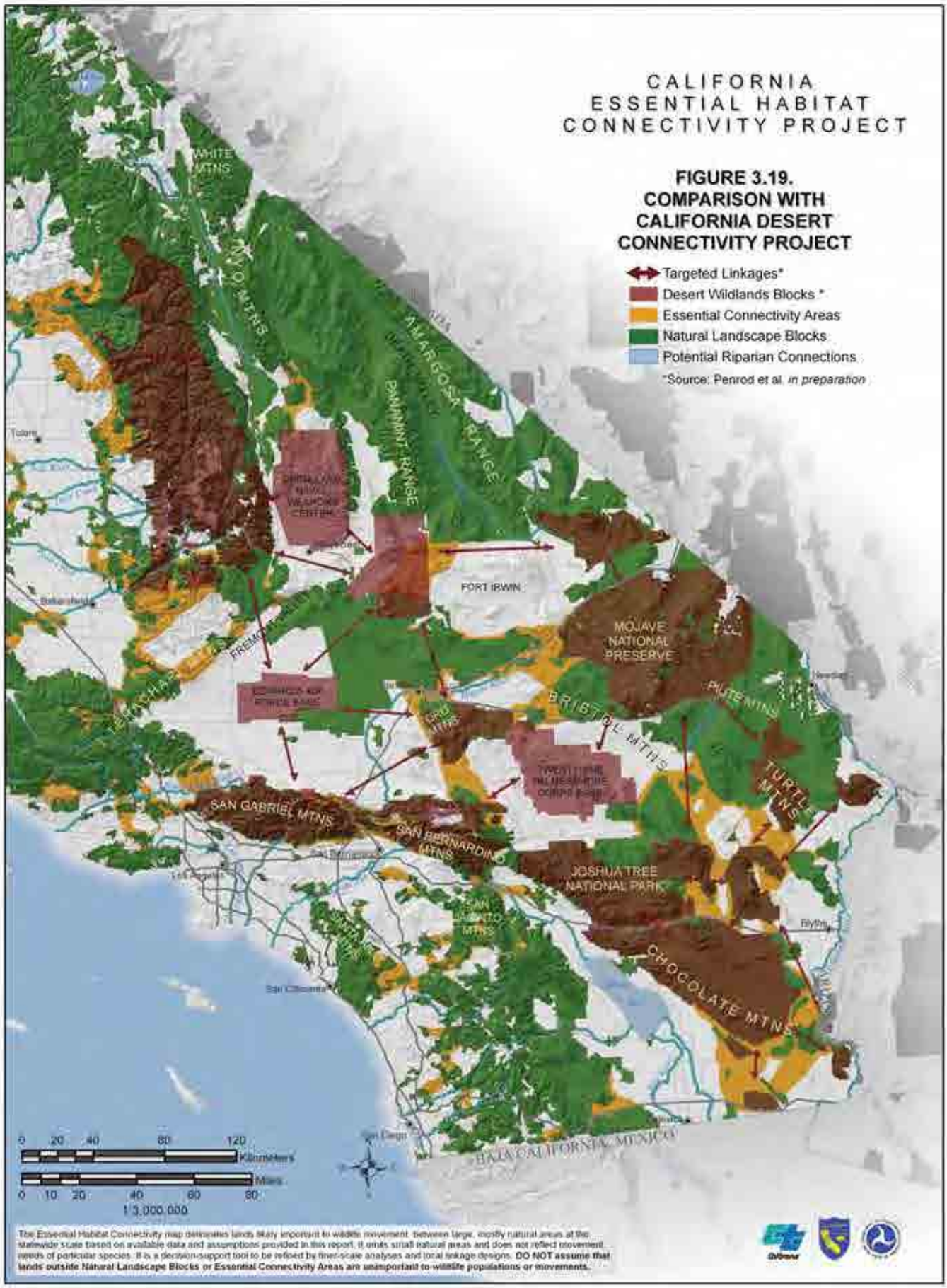
Targeted wildland blocks for this effort are GAP 1, 2, and 3 lands, which primarily include National Parks, Preserves, National Forests, Bureau of Land Management Wilderness Areas, and lands administered by the Department of Defense. Twenty-three linkages are being addressed that scored high in terms of biological irreplaceability and threat based on a formal evaluation of 47 potential connections in the desert. The project is addressing the habitat and movement requirements of 47 focal species (10 amphibians and reptiles, 13 mammals, 10 birds, 9 plants, and 5 invertebrates). Eighteen of the 23 targeted linkages being addressed by the California Desert Connectivity Project are fairly well captured by the Essential Habitat Connectivity Map, though the Essential Connectivity Areas will certainly be refined and improved based on the focal species analyses currently being conducted for the project (Figure 3.19). Four out of five of the targeted linkages not addressed by the network are intended to provide connectivity to Department of Defense lands, which were not captured as Natural Landscape Blocks due to the strict criteria used to define these in the desert ecoregions.

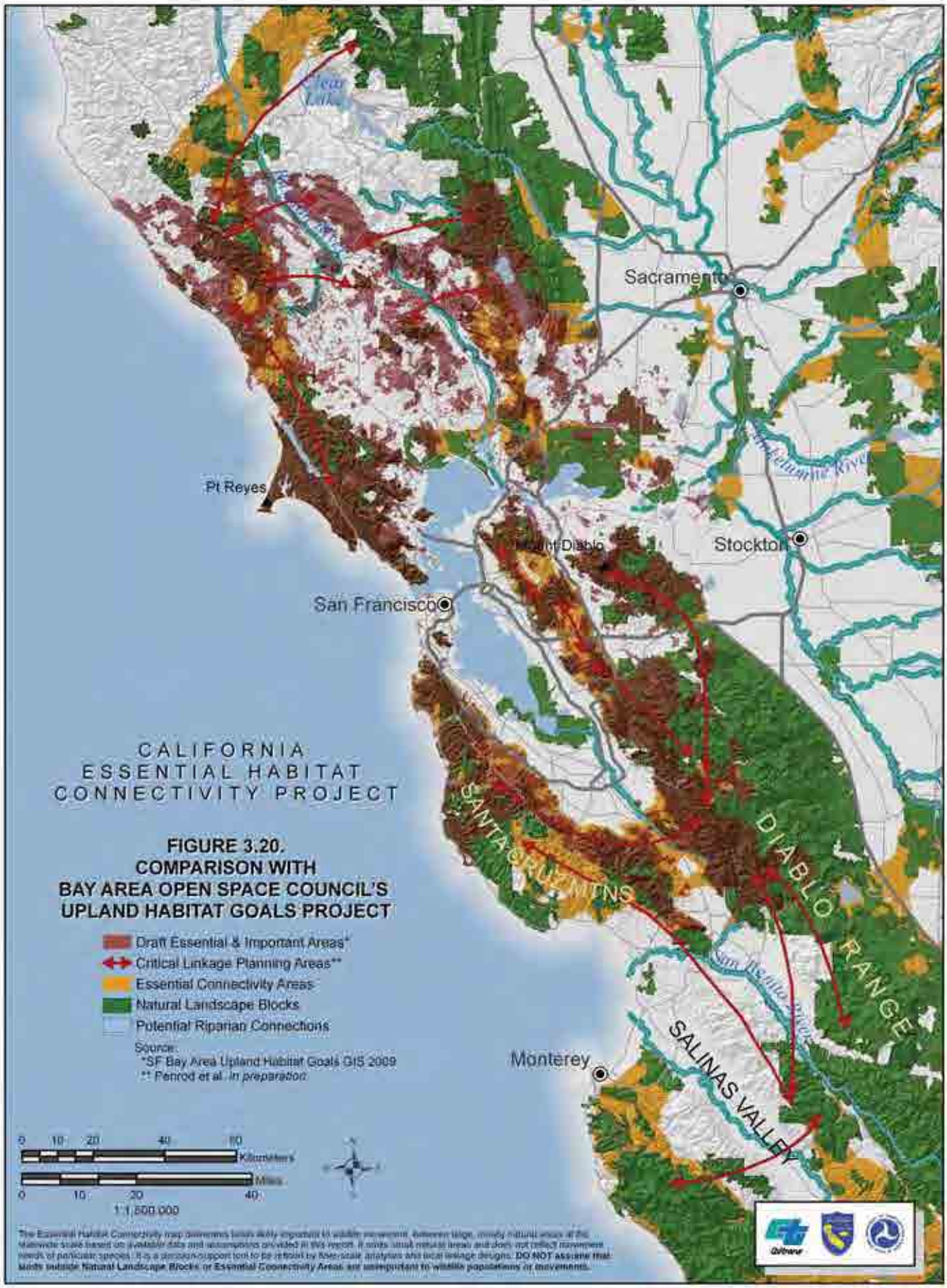
3.3.11. Bay Area Open Space Council's Upland Habitat Goals Project

The San Francisco Bay Area Upland Habitat Goals Project (www.openspacecouncil.org) is a science-based effort to promote landscape-level conservation in nine counties in the Bay Area (Weiss et al. 2008). A Draft Conservation Lands Network was generated using MARXAN software, which allows the analyst to assess multiple factors, such as conservation targets, goals, land use, adjacency to protected lands, and the ecological integrity of the landscape. The Upland Goals Project used MARXAN to identify "essential" and "important" areas. The resulting GIS database and reference document are decision-support tools to inform and support agencies and organizations seeking to preserve, enhance and restore the biological diversity of upland habitats in the region (Weiss et al. 2008).

The Upland Habitat Goals Project establishes a blueprint for core area delineation. A recently initiated project, Bay Area Critical Linkages, will add to that blueprint by completing 12 to 15 detailed Linkage Designs to ensure connectivity and thus viability of large core conservation areas. The comprehensive linkages strategy will include focal species-based Linkage Designs, based on the methodology developed for the South Coast Missing Linkages Project (Beier et al. 2006), implementation strategies and tools, and a monitoring framework.

The Upland Habitat Goals Project is still in draft form and is slated for completion in mid 2010. Using the project's Draft Conservation Lands Network, 68% of the network was captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (Figure 3.20). If we compare the network to only essential conservation areas, the overlap increases to 70%, while 18% of the important conservation priorities are captured. Eight of the 15 planning areas identified by the Bay Area Critical Linkages Project were addressed by the coarse-scale statewide network developed by the California Essential Habitat Connectivity Project, which further highlights the need for local-scale, focal-species analyses that will be carried out as part of the Bay Area Critical Linkages Project. The notable target


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.19.
COMPARISON WITH
CALIFORNIA DESERT
CONNECTIVITY PROJECT
Targeted Linkages*
Desert Wildlands Blocks *
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: Penrod et al. in preparation
WHITE MTNS
INYO MTNS
AMARGOSA RANGE
PANAMINT RANGE
FORT IRWIN
MOJAVE NATIONAL PRESERVE
BRISTOL MTNS
PIUTE MTNS
TURTLE MTNS
SAN GABRIEL MTNS
SAN BERNARDINO MTNS
JOSHUA TREE NATIONAL PARK
CHOCOLATE MTNS
BAJA CALIFORNIA, MEXICO
0 20 40 80 120
Kilometers
Miles
0 10 20 40 60 80
1:3,000,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.


Sacramento
Pt Reyes
Mount Diablo
Stockton
San Francisco
Monterey
CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.20.
COMPARISON WITH
BAY AREA OPEN SPACE COUNCIL'S
UPLAND HABITAT GOALS PROJECT
Draft Essential & Important Areas*
Critical Linkage Planning Areas**
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
Source:
*SF Bay Area Upland Habitat Goals GIS 2009
** Penrod et al. In preparation
SANTA CRUZ MTNS
DIABLO RANGE
SALINAS VALLEY
0 10 20 40 60
Kilometers
0 10 20 40
Miles
1:1,500,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas of the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by fine-scale analysis and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

areas that were not included as Natural Landscape Blocks in the Essential Habitat Connectivity Map are the northern and southern Mayacamas Mountains, while key connections not captured by the network include the Santa Cruz Mountains to the Gabilan Range and connections to the Santa Lucia Range through the Salinas Valley. These same connections were also identified by the Central Coast Network (Thorne et al. 2002).

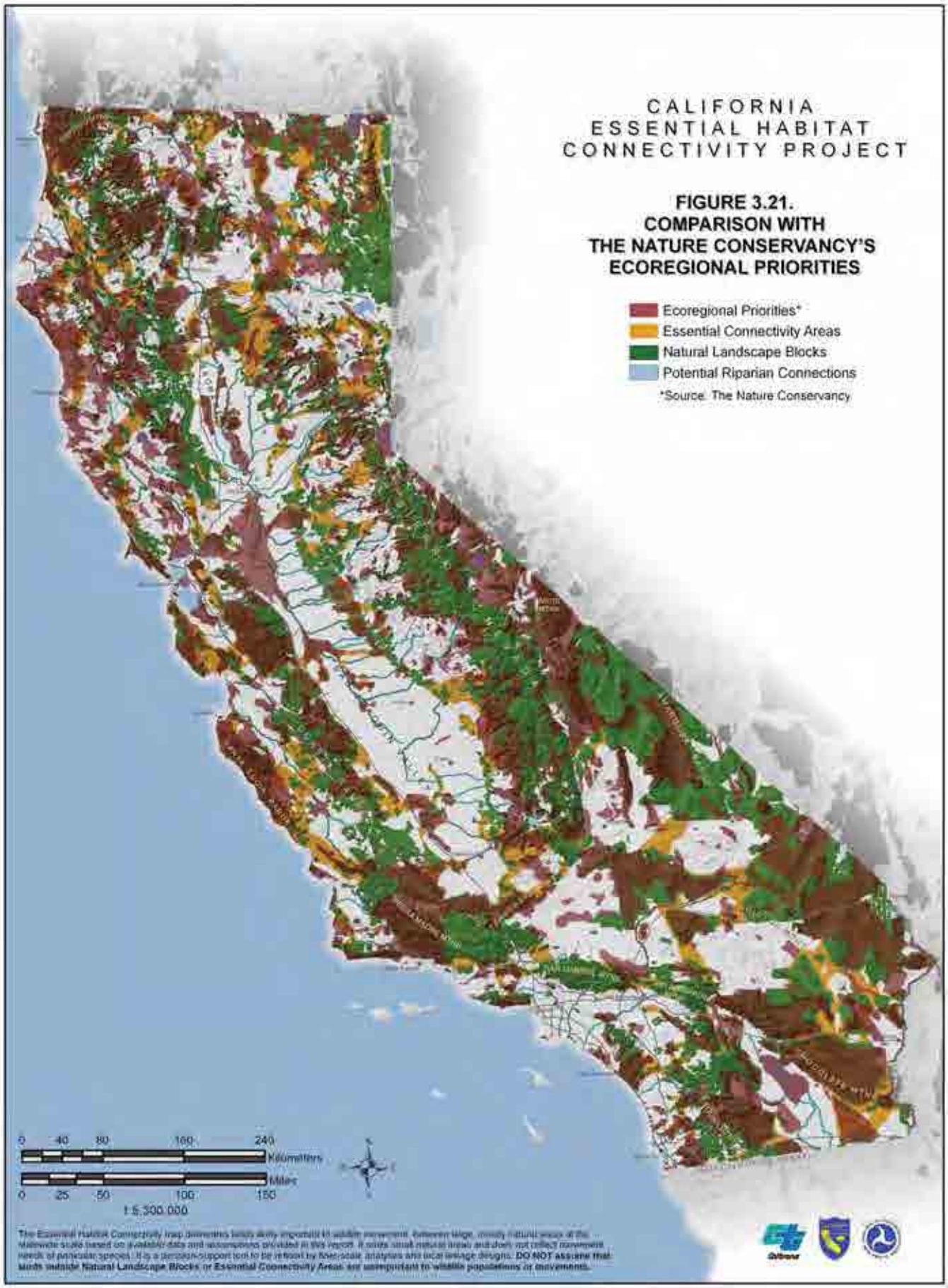
3.3.12. The Nature Conservancy's Ecoregional Priorities

The Nature Conservancy identifies its ecoregion-based priorities through a rigorous, iterative process involving five major steps: (1) identifying conservation targets, (2) gathering information, (3) setting goals, (4) assessing viability, and (5) assembling portfolios. The first step is to identify conservation targets or the species, natural communities, and ecosystems in a given ecoregion. The next step is to gather data about these conservation targets from a variety of sources, including Natural Heritage programs, satellite images, and rapid ecological assessments. Once the data are gathered, goals are set for each conservation target based on how much is needed and in what distribution to ensure long-term survival of each target. The ecoregional planning team then assesses the viability of each occurrence of each conservation target to ensure survival over the long term by choosing the best and most healthy examples of each target. All this information is analyzed to design an efficient network of conservation areas (or portfolio) that if protected in its entirety will ensure the preservation of biodiversity within an ecoregion (www.nature.org).

The Nature Conservancy has delineated 41.2 million acres throughout the state as conservation priorities or portfolio sites, with 36.8 million ac in terrestrial ecosystems, 347,391 acres in marine ecosystems, and 4.1 million ac in aquatic ecosystems. A total of 69% of the compiled portfolio sites were captured by the California Essential Habitat Connectivity Project's network of Natural Landscape Blocks (58% or 24.1 million ac) and Essential Connectivity Areas (10% or 7,008 ac; Figure 3.21; Table 3.16). That number goes up slightly to 72% if we compare only the terrestrial based portfolio sites, which are more closely aligned with the Essential Habitat Connectivity Map. Note that the focus of portfolio sites is on areas *in need of protection*, whereas our Natural Landscape Blocks tend to include mostly *already protected* lands, one would not necessarily expect high overlap between the two.

Table 3.16. Overlap between Essential Habitat Connectivity Map and The Nature Conservancy's Portfolio Sites in California.

	Terrestrial		Marine		Aquatic	
Description of Comparison	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Portfolio Overlap with NLBs	22,658,506	62%	99,317	29%	1,308,796	32%
Portfolio Overlap with ECAs	3,779,346	10%	17,273	5%	482,661	12%
Portfolio Overlap by Network	26,437,852	72%	116,589	34%	1,791,455	44%


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.21.
COMPARISON WITH
THE NATURE CONSERVANCY'S
ECOREGIONAL PRIORITIES
Ecoregional Priorities*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: The Nature Conservancy
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement, between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

3.3.13. California Rangeland Conservation Coalition Focus Areas

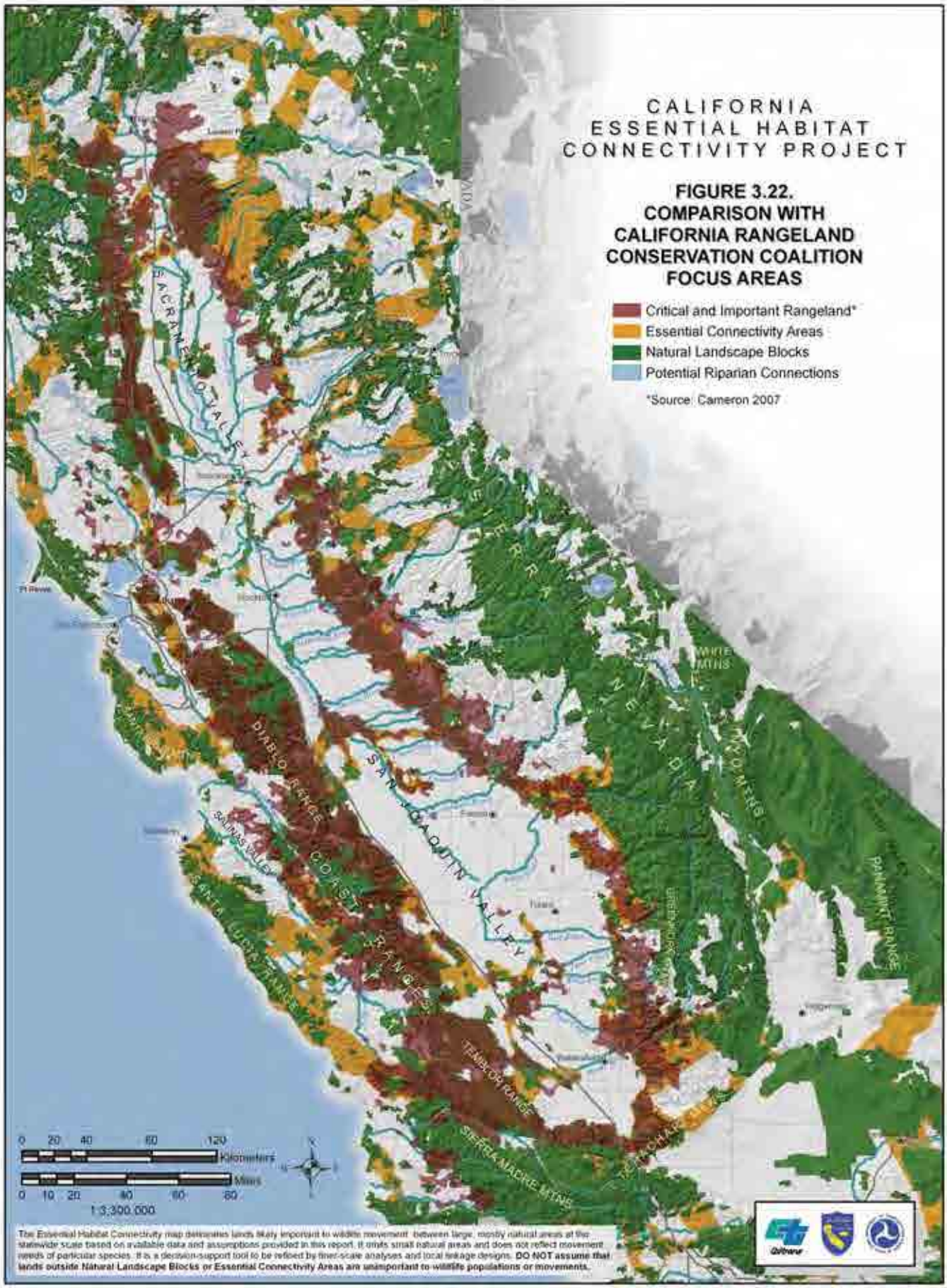
The California Rangeland Conservation Coalition (www.carangeland.org) is a consortium of ranchers, resource professionals from federal and state agencies, and environmentalists who have been working together since 2005 to conserve and enhance rangelands of high biological value encircling the Central Valley, including the Sierra foothills and interior Coast Ranges, while maintaining a viable ranching industry. Rangelands have been identified as one of the most threatened habitats in the western United States (Maestas et al. 2003, Theobald 2005, Cameron 2007). As such, the Coalition prioritized areas of privately owned rangelands encircling California's Central Valley that have high biodiversity value and require conservation action in the next 2-10 years (Cameron 2007).

Conservation targets integrated into the prioritization process included terrestrial systems and communities (i.e., grassland, blue oak woodland, riparian woodland and scrub, vernal pools) and several species (Cameron 2007). Rare, endemic, or sensitive rangeland animals considered conservation targets included blunt-nosed leopard lizard (*Gambelia sila*), giant kangaroo rat (*Dipodomys ingens*), riparian woodrat (*Neotoma fuscipes riparia*), San Joaquin antelope squirrel (*Ammospermophilus nelsoni*), San Joaquin kit fox, San Joaquin pocket mouse (*Perognathus inornatus*), short-nosed kangaroo rat (*Dipodomys nitratoides brevina*), Tipton kangaroo rat (*Dipodomys nitratoides nitratoides*), Tulare grasshopper mouse (*Onychomys torridus tularensis*), and Fresno kangaroo rat. Breeding and winter grassland birds considered conservation targets included loggerhead shrike (*Lanius ludovicianus*), northern harrier (*Circus cyaneus*), lark sparrow (*Chondestes grammacus*), ferruginous hawk (*Buteo regalis*; winter only), prairie falcon (*Falco mexicanus*), and white-tailed kite (*Elanus leucurus*). Two anadromous fish were also considered conservation targets including steelhead trout (Central Coast Evolutionary Significant Unit [ESU] and Central Valley ESU) and spring-run chinook salmon (*Oncorhynchus tshawytscha*; Central Valley ESU). This process identified 9.7 million acres of priority rangelands, delineating 6.4 million acres as critical and 3.3 million acres as important.

Approximately 73% of the priority rangelands were captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (58% or 5.6 million ac) and Essential Connectivity Areas (15% or 1.4 million ac), including 49% delineated as critical rangeland and 24% identified as important rangeland (Figure 3.22; Table 3.17). The tremendous overlap emphasizes the critical role that working landscapes can play in maintaining functional connectivity across the landscape.

Table 3.17. Overlap between Essential Habitat Connectivity Map and California Rangeland Conservation Coalition Focus Areas.

	Total Rangeland Overlap (acres)	Total Percent	Critical Rangeland (acres)	Total Percent	Important Rangeland (acres)	Total Percent
Rangeland overlap NLBs	5,623,785	58%	3,835,408	40%	1,788,377	19%
Rangeland overlap ECAs	1,404,272	15%	861,148	9%	543,124	6%
Rangeland overlap total network	**7,028,057**	**73%**	**4,696,557**	**49%**	**2,331,500**	**24%**


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.22.
COMPARISON WITH
CALIFORNIA RANGELAND
CONSERVATION COALITION
FOCUS AREAS
Critical and Important Rangeland*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: Cameron 2007
SACRAMENTO VALLEY
SIERRA NEVADA
WHITE MTNS
INYO MTNS
PANAMINT RANGE
DIABLO RANGE
SAN JOAQUIN VALLEY
SALINAS VALLEY
COAST RANGES
SANTA LUCIA RANGE
TEHACHAPI MTNS
SIERRA MADRE MTNS
0 20 40 60 120
Kilometers
Miles
0 10 20 40 60 80
1:3,300,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

3.3.14. Audubon's Important Bird Areas

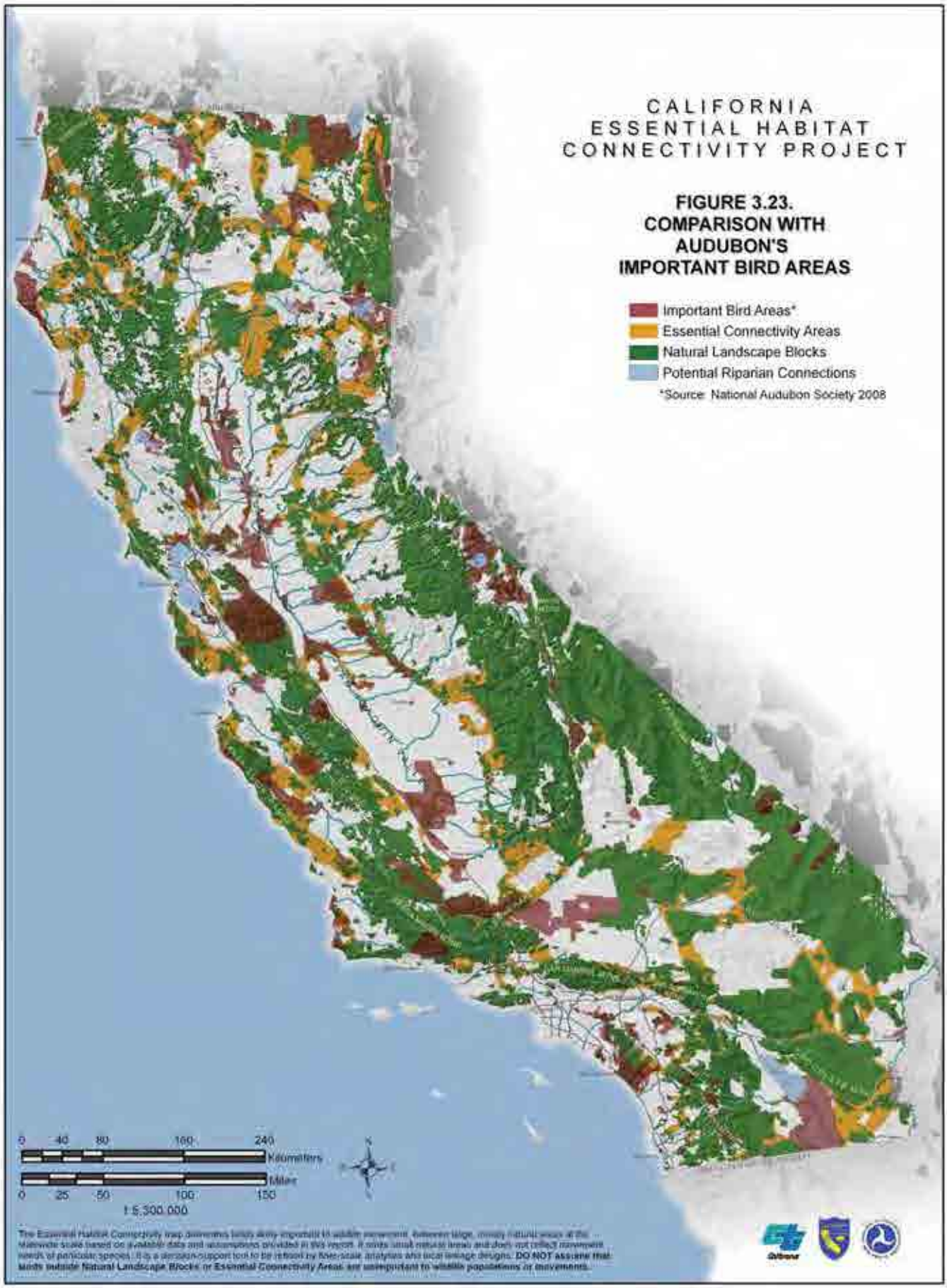
Important Bird Areas identify and promote conservation of habitats supporting avian biodiversity (National Audubon Society 2008). This international program was initiated in 1985 due to concerns about the loss and fragmentation of important bird habitat. The National Audubon Society (2008) describes Important Bird Areas as "sites that provide essential habitat for (i) rare, threatened or endangered birds, (ii) exceptionally large congregations of shorebirds, or (iii) exceptionally large congregations of waterfowl." The designation of a site as an Important Bird Area, while providing no regulatory authority, can be used to leverage conservation efforts that help to conserve essential bird habitat in the state.

As of 2008, over 10,000 Important Bird Areas have been designated worldwide, including 145 in California. The California Important Bird Areas range in size from 16 acres (Pier 400 Tern Colony) to 624,000 acres (Imperial Valley). Important Bird Areas on mainland California occupy approximately 10.7 million acres throughout the state, of which roughly 1.3 million acres are covered by open water (e.g., lakes, reservoirs, bays) that were not included when generating comparison statistics.

Approximately 53% of the Important Bird Areas were captured by the Essential Habitat Connectivity Map's network of Natural Landscape Blocks (43% or 4.1 million ac) and Essential Connectivity Areas (9% or 0.9 million ac; Figure 3.23), with the network capturing 58% or greater in most Important Bird Area Regions (Table 3.18). The low proportion of overlap in the desert ecoregions is due in part to the strict criteria used to delineate Natural Landscape Blocks in the desert which excluded Edwards Air Force Base. In addition, the Important Bird Area south of the Salton Sea is dominated by agricultural lands, which affected the Ecological Condition Index used to define Natural Landscape Blocks; the same is true for Important Bird Areas excluded from the network in the Sacramento Valley.

Table 3.18. Overlap between Essential Habitat Connectivity Map and Audubon Society Important Bird Areas by Region.

Important Bird Area Regions	IBA Area (acres)	Overlap with NLBs (acres)	Overlap with ECAs (acres)	Percent Covered by Network
Central Coast	773,196	340,031	212,413	71%
Colorado - Mojave Desert	1,694,568	365,017	32,278	23%
North Coast - Klamath	681,808	186,324	24,497	31%
Sacramento Valley	722,184	131,328	50,369	25%
San Francisco Bay Area	958,200	701,114	83,151	82%
San Joaquin Valley	1,875,823	964,767	257,659	65%
Sierra Nevada - Modoc	1,971,820	982,696	170,978	59%
South Coast	736,139	385,325	57,959	60%
Total	**9,413,739**	**4,056,601**	**889,304**	**53%**


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 3.23.
COMPARISON WITH
AUDUBON'S
IMPORTANT BIRD AREAS
Important Bird Areas*
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
*Source: National Audubon Society 2008
0 40 80 160 240
Kilometers
Miles
0 25 50 100 150
1:5,300,000
N
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement, between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

Chapter 4. Framework for Regional Analyses

This Report provides a map of large Natural Landscape Blocks and Essential Connectivity Areas throughout the State of California. If conserved and restored, this network of wildlands should help support interacting wildlife populations, evolutionary processes, and range shifts of species in a changing climate. This large, linked network is essential to support large carnivores, large gene pools, and high species diversity that can flow also into smaller natural areas. But this network excludes natural areas smaller than 10,000 acres (in the deserts, Sierra Nevada, and other relatively intact ecoregions) or 2,000 acres (in the Central Valley and other highly fragmented ecoregions). In this Chapter, we present approaches to mapping natural areas and connectivity areas at the regional (sub-state) scale.

Are regional analyses necessary? Can they sometimes delay on-the ground conservation? If one's goal is to develop a detailed action plan for one or several of the Essential Connectivity Areas described in this Report, one could bypass regional analyses altogether and proceed directly to Linkage Design as described in Chapter 5. Indeed, a proposed development or agricultural conversion project that might adversely impact an Essential Connectivity Area should trigger the development of a Linkage Design for that Essential Connectivity Area, regardless of whether a regional analysis has been conducted. The lack of a regional-scale analysis should not be used as an excuse to avoid or delay local-scale analysis.

Why conduct regional analyses? First, these analyses help planners comprehensively consider regional needs for connectivity, including needs of natural areas smaller than considered in this statewide Report. Second, prioritization among connectivity areas is probably best done at a regional scale, for biogeographic and geopolitical reasons described below. Regional prioritization is important because it allows planners to focus local-scale analyses (Chapter 5) in the most critical or most threatened connectivity areas. Additionally, regional analyses allow for more involvement and input from scientists and planners with local knowledge and can help rectify errors of omission in the statewide network. Finally, regional analyses can take advantage of spatial datasets that we could not use in this report because the datasets did not cover the entire state.

4.1. Defining the Region

During the process of conducting the statewide analysis, determinations regarding delineating the Natural Landscape Blocks were made with the state scale in mind. For analysis at a finer scale, the following are key considerations in defining a region:

- It should be small enough that natural areas smaller than 10,000 acres can be mapped and considered, but large enough to be meaningful for assessing a network of landscape blocks and connectivity areas.
- It should comprise an area of relatively homogeneous environmental and planning context. Although every region in California is heterogeneous, planning is more efficient if similar problems and strategies apply to most of the region.

The Jepson Manual (Hickman 1993) recognizes 10 ecoregions in California: North Coast Mountains, Modoc Plateau, Cascades, Sierra Nevada, Eastern Sierra Nevada, Central Valley, Mojave Desert, Sonoran Desert, South Coast, and Central Coast Mountains. Following Penrod et al. (2001), this Report lumped these into eight ecoregions by considering the Cascades part of the Modoc Plateau and the Eastern Sierra Nevada part of the Sierra Nevada (although we subsequently subdivided two ecoregions based on development patterns). Jepson ecoregions or USDA ecological sections or subsections (Miles and Goudey 1998) are appropriate units for regional analyses of connectivity because each ecoregion has relatively homogeneous vegetation, animal species, and human impacts on the landscape. In California, analyses for Jepson ecoregions have been conducted for the Central Coast (Thorne et al. 2002), South Coast (2003-2006; www.scwildlands.org), Central Valley (Huber et al. 2010) and are currently being developed for the Mohave-Sonoran Deserts (2009-2011, also by SC Wildlands).

Alternatively, the region can be defined by administrative boundaries, such as the boundaries of a Caltrans district, a California Department of Fish and Game Region, a Metropolitan Planning Organization, an Association of Governments, or a Natural Community Conservation Plan. It may be desirable to use a hybrid regional scheme that is both biological and organizational, such as the bioregions adopted by the California Biodiversity Council (http://biodiversity.ca.gov/bioregions.html). Funding agencies also can define the region, as occurred for the Bay Area Critical Linkages Project (2010-2011). In this case, the region is coextensive with the northern part of the Central Coast Jepson ecoregion as defined in this Report and extends into the southern part of the North Coast Jepson ecoregion. As long as the key factors listed above are considered, there are other good ways to define a region.

4.2. Products of a Regional Connectivity Analysis

Ideally, the products of a regional connectivity analysis would include all of the following bulleted items. At a minimum, it should include the first two items.

- A map of natural landscape blocks and connectivity areas in the region, including some connectivity areas that extend beyond the boundary of the region. We address this in detail in Section 4.3.
- Documentation, descriptions, and strategies related to the map. The analogous sections of this Report provide a good template for these products.
- A list of a subset of connectivity areas most crucial to ecological integrity of the region. We address this in detail in Section 4.4.
- For each connectivity area identified as most crucial, a Linkage Design produced by local-scale analysis (Chapter 5).

The most well-known example of a regional analysis is South Coast Missing Linkages (Figure 4.1; South Coast Wildlands 2008, Beier et al. 2006) and the accompanying 11 individual Linkage Designs for the South Coast Ecoregion (available at www.scwildlands.org). Figure 4.1 depicts the major protected Natural Landscape Blocks in green, and the Linkage Designs for the 11 most important connectivity areas in red. The

Linkage Designs were developed based on the habitat and movement needs of multiple focal species and all but one (i.e., San Bernardino-Granite) are being actively implemented. The South Coast ecoregion contains an additional 58 connectivity areas (not depicted on the map below) that were identified in the 2001 statewide Missing Linkages effort (Penrod et al. 2001). Future work is needed to identify the next set of priority connectivity areas and develop Linkage Designs for them, as outlined in Chapter 5. This South Coast ecoregional analysis included detailed Linkage Designs to adjacent ecoregions within California. One shortcoming of the effort was that, due to data limitations and cultural sensitivities, the project was not able to provide detailed Linkage Designs for three critical linkages crossing into neighboring Baja California, Mexico; however, the need for cross-border connectivity is being addressed via other avenues[26]. Future regional analyses could also improve on the South Coast Missing Linkages analysis by using formal procedures to consider climate change. Nonetheless, South Coast Missing Linkages remains a useful example for future efforts.

Figure 4.1. South Coast Missing Linkages includes Linkage Designs for the 11 most important connectivity areas (red polygons) among the major protected Natural Landscape Blocks (green).

[26] Cross-border planning with Mexican agencies and non-governmental organizations is happening through a separate venue, the Las Californias Binational Conservation Initiative (http://consbio.org/what-we-do/las-californias-binational-conservation-initiative/?searchterm=las%20californias).

4.3. Producing a Regional Map of Natural Landscape Blocks and Connectivity Areas

In this section we describe three key steps for producing a regional map of Natural Landscape Blocks and Connectivity Areas, and several options for each of these steps. We offer these recommendations to developers of a regional analysis:

- Involve the end-users early in the design process. The users should collectively agree on what types of areas they want to connect, which areas need connectivity, and which areas merit the highest priority for detailed Linkage Designs.
- Insist on data layers and criteria that can be applied across the entire region. Avoid data that were collected in only part of the region, because this creates a bias against poorly studied areas.
- Insist that each attribute layer is produced by a quantitative procedure rather than expert opinion. For instance, if a binary attribute such as "important for seasonal migration" or "important for climate change" is to be used, the attribute must be operationally defined and consistently applied across the landscape, rather than subjectively assigned to each polygon by expert opinion[27].
- Strive to make the entire process as transparent and repeatable as possible. Users rightly distrust black boxes. It is also easier to update a transparent analysis as new or better data become available.

4.3.1. Delineate Natural Landscape Blocks

Connectivity is meaningful only with reference to what is being connected. The following approaches – or combinations of them – can be used to define wildland blocks:

1. Hold an *expert workshop* at which knowledgeable participants draw polygons on a map.
2. Select areas of *high ecological integrity*, such as low road density, and low proportion of area converted to urban, agricultural, or industrial use.
3. Select *protected areas* – areas where biodiversity and natural landscape character are protected by law or landowner mission.
4. Use *optimization techniques*, such as *simulated annealing*, to identify areas that meet quantitative biodiversity targets in a compact area.
5. Use a *map that another agency has already developed to conserve biodiversity* (e.g., The Nature Conservancy's Ecoregional Priorities, biodiversity hotspots, CDFG Areas of Conservation Emphasis, Critical Habitat for listed species).
6. Develop maps of *modeled habitat for a suite of species*.

[27] Expert opinion may be used to score attribute classes, e.g., to assign one score to all polygons that support migration and another score to polygons that do not support migration, as long as the underlying map is generated by a consistent procedure.

7. Use *highways* either to split Natural Landscape Blocks or to modify preliminary blocks developed by one of the above procedures.

For the statewide map in this Report, we identified preliminary Natural Landscape Blocks as areas of *high ecological integrity* (#2) or areas of *high protection status* (#3), as modified by mapped *biodiversity areas* (#5). We further modified the Natural Landscape Blocks by splitting them at each major or secondary *highway crossing* (#7). Although we recommend our combination of approaches, we describe the advantages and disadvantages of each approach so that developers of regional analyses can make choices that are most favored by end users.

4.3.1.1. EXPERT WORKSHOPS

An expert workshop is an efficient way to draw on the knowledge of the many people who know the status of biodiversity across the region. Much of their knowledge comes from unpublished information and personal familiarity with diverse landscapes. The approach is efficient, in that large areas can be mapped in a short time at low cost. For example, in a one-day statewide workshop at the San Diego Zoo in November 2000, some 200 participants developed a map of hundreds of Natural Landscape Blocks and potential linkages across the State of California (Penrod et al. 2001).

The downside of this approach is that the process is not transparent, quantitative, and repeatable, and the outputs tend to be vague. For instance, the 2001 Missing Linkages report did not clearly map the Natural Landscape Blocks. Although the report raised the level of awareness of connectivity throughout the state, its vagueness and lack of rigor limited the degree to which it could be used as a decision support tool.

4.3.1.2. AREAS OF HIGH ECOLOGICAL INTEGRITY

In this approach, the landscape is portrayed in a Geographic Information System (GIS) as a grid of squares, typically 30 m to 200 m on a side. Such a grid is called a *raster*, and each square is called a *pixel*. Ecological integrity of each pixel is calculated as a function of attributes that are quantified for every pixel in the analysis area. Pixel attributes related to ecological integrity may include landcover, land use, urban area density, distance to nearest road, road density near the pixel (measured as length of road per unit area), or other variables. Then contiguous clusters of pixels that are good enough (above a certain threshold ecological integrity) and big enough (above a minimum area threshold) are identified as Natural Landscape Blocks. The analyst may also impose a shape requirement, so that an elongated strip of natural land, such as power line right of way in an urban area, is not considered a Natural Landscape Block.

In this Report, we used Ecological Integrity (Davis et al. 2003, 2006) as the main determinant of Natural Landscape Blocks (Chapter 2). The attributes used to define Natural Landscape Blocks were proportion of land in natural landcover, distance to road (weighted by road class and traffic volume), forest structure (for forest types that have potential for commercial timber extraction), and housing density (houses per acre).

We recommend Ecological Integrity as the main determinant of Natural Landscape Blocks in regional analyses, because this approach efficiently identifies large natural areas, even if they are unprotected. The approach is transparent, repeatable, and relatively simple. Hoctor et al. (2000), Carr et al. (2002), and Marulli and Mallarach (2005) also used Ecological Integrity to define Natural Landscape Blocks. In conducting a regional analysis, the analyst must work with scientists and other end users to select the following attributes:

- Pixel attributes. We offer the following recommendations:
  - Use only a small number of attributes. Models with too many attributes lack transparency and risk becoming black boxes that lose stakeholder trust.
  - Proportion of land in natural landcover should be one of the attributes. In regions that are highly dominated by agriculture or other human uses, it may be appropriate to identify lands with high restoration potential, and to assign them a score that recognizes this potential.
  - Some variable related to roads, such as distance to highway or paved road, should be one of the attributes.
  - If an attribute related to housing density is used, be careful with the US Census Block data. Census Blocks vary in size and shape, and the Census Bureau does not report where houses occur within the Census Block. In our statewide analysis, when a heavily-populated Census Block extended into an unpopulated natural area, all pixels in the Census Block, even those in pristine areas, were assigned the average housing density of that Block. Because our Natural Landscape Blocks were large, these errors probably had minimal impact on our statewide analysis, but they could cause a regional analysis to fail to recognize some small but important Natural Landscape Blocks in or near heavily-populated areas. If the region is small enough, the analyst can overlay census blocks on an air photo or other suitable data layer, and split the "problem" Census Blocks. Alternatively, road density may be a good surrogate for housing density in a region.
- Pixel size. We recommend a pixel size consistent with the finest data layer used in the analysis, typically 30 m.
- Moving window size for attributes expressed as ratios (such as proportion of land in natural state or miles of road per square mile), spatial averages (such as average housing density or average forest canopy closure), or distances at which an effect becomes negligible (such as distance from a road or urban edge). To select a moving window size, one can start with a range of estimates from relevant literature (e.g., on edge effects), and then try distances within that range and judge whether the resulting map looks reasonable. Most analysts find that a moving window radius or distance of 100 m to 500 m provides reasonable results.
- Whether to combine attributes using Boolean functions, arithmetic mean, arithmetic sum, geometric mean, or some combination of these functions. Boolean functions and geometric means sometimes better reflect the situation where deficiency in one attribute cannot be compensated by good values for other attributes. As with the previous decision, some trial-and-error is useful. Again, we recommend keeping the process as transparent as possible.

- Minimum size threshold to qualify as a Natural Landscape Block. Many end users will want a low threshold, and the analyst should try to meet this demand, unless it produces an unreadable map or cannot be justified with existing data.
- Whether to impose a shape requirement to avoid designating a long, narrow, highly edge-affected area as a Natural Landscape Block. The opinions of end users should be decisive on this matter. In a GIS, such areas can readily be identified as potential blocks whose entire area is less than a specified distance from the block's edge.

4.3.1.3. PROTECTED AREAS

In this approach, the analyst selects all parcels that meet a certain level of protection, such as all lands in certain GAP[28] protection status. Contiguous parcels above the threshold protection status and above the minimum size threshold are designated as Natural Landscape Blocks. The approach is straightforward and unambiguous. The resulting connectivity map connects only to existing conservation investments, precluding "corridors to nowhere" – i.e., mapped connections to lands that could be developed in the future. The downside of the approach is that it "writes off" natural landscapes that are not currently protected. In some regions, the majority of large natural landscapes may be privately owned and unprotected. Some of these areas may be at low risk of development due to rugged terrain or lack of access to water, and others could be conserved in the future.

Because using protection status as the sole determinant of a Natural Landscape Block would fail to recognize some valuable wild landscapes, we recommend using protection status in conjunction with ecological integrity, as we did in Chapter 2.

4.3.1.4. SIMULATED ANNEALING

The basic idea behind simulated annealing (Ball and Possingham 2000, Possingham et al. 2000) is to depict the landscape either as a grid of cells, or as a group of irregularly shaped polygons (e.g., watersheds, ownership parcels). The analyst must have an estimate of how much each grid cell or polygon can contribute to biodiversity targets. The targets are typically to achieve a certain number of occurrences of each species, or each type of natural vegetation community, and to do so at the smallest cost. Two aspects of cost are generally considered: total land area (which can be expressed in dollars if land values of different parcels are known) and the amount of edge (cost of managing a protected area and ensuring its integrity increases with amount of edge). The combination of cells or polygons that achieves all targets at the lowest cost is the optimal solution.

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[28] GAP protection status (Crist 2000). Status 1: permanent protection from conversion of natural landcover and a mandated management plan to maintain a natural state and disturbance events, e.g., designated wilderness, national parks. Status 2: permanent protection from conversion of natural landcover and a mandated management plan to maintain a primarily natural state, but may receive uses that degrade the quality of existing natural communities, including suppression of natural disturbance. Status 3: permanent protection from conversion of natural landcover for most of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining); protection to federally listed species throughout the area. Status 4: no public or private mandates or easements prevent conversion of natural habitat types to anthropogenic habitat types.

Mathematically, finding the optimal solution is difficult. With only 100 polygons, there are over a trillion quadrillion possible combinations of polygons to evaluate; for larger landscapes, the problem is worse. Fortunately, ecologists at University of Queensland developed an approach that efficiently identifies optimal or near-optimal solutions. They have packaged this as the software program MARXAN, freely available at http://www.uq.edu.au/marxan/. An excellent, non-technical, illustrated overview of the procedure is available at http://www.mosaic-conservation.org/cluz/marxan_intro.html. An earlier version of MARXAN is SITES, which has been used by The Nature Conservancy in many ecoregional assessments in the US. CLUZ is an ArcView extension that provides an interface between MARXAN (which uses text-based input files) and GIS datasets.

We suggest caution in using simulated annealing to define Natural Landscape Blocks, because connectivity should not be limited solely to the smallest landscape areas needed to meet identified goals. Such a procedure is appropriate when one is allocating scarce dollars for acquisition or easements. But connectivity planners typically want to maintain or improve connectivity to all wildland blocks – not just those that contain high biodiversity or meet other goals in a small area. Therefore we recommend procedures that identify large, intact natural landscape areas in their entirety, rather than the smallest portion necessary to meet specified goals.

4.3.1.5. EXISTING CONSERVATION MAPS

Many agencies have developed maps to conserve biodiversity that cover broad regions. For example, The Nature Conservancy has developed maps of conservation priorities in most states and ecoregions. California Department of Fish and Game is developing a series of data layers to identify Areas of Conservation Emphasis. The US Fish and Wildlife Service has designated Critical Habitat for many species listed under the Endangered Species Act. All such maps depict areas with documented value to biodiversity, and thus seem appropriate for designation as Natural Landscape Blocks. This approach has two disadvantages. First, it can fail to recognize biodiversity "coldspots" – that is, those large, functioning ecosystems that lack high biodiversity or special status species (Karieva and Marvier 2003) but may nevertheless be important to conserving natural communities, biodiversity, and ecological functions. Second, some designated Critical Habitat and some rare species occurrences occur in highly degraded, un-natural landscapes, and some rare endemic plants or insects may occur in small, naturally-isolated populations that do not need connectivity.

In light of these disadvantages, we recommend using mapped biological values as modifiers to ecological integrity in designating Natural Landscape Blocks in a regional analysis, as we did in this statewide Report (see Chapter 2). In selecting data layers, we recommend map layers that cover the entire region. In this regard the Bureau of Land Management Areas of Critical Environmental Concern (ACEC) was a less than ideal data layer because those Areas are designated exclusively on federal land.

4.3.1.6. HABITAT CORES FOR A SUITE OF SPECIES

Few US states or ecoregions have defined Natural Landscape Blocks based on habitat cores for a suite of species. Huber et al. (2010) defined cores in the Great Central Valley using several focal species. Colorado initiated a focal species approach in 2005, and Washington

state initiated one in September 2008, with a target date of late 2010 for the statewide map[29]. In Colorado, the Southern Rockies Ecosystem Project (2005) convened expert workshops that produced hand-drawn habitat core areas for 27 focal species, and 176 hand-drawn linkage areas among these core areas; the planned Phase II mapping has yet to occur. The Washington effort selected 16 focal species to represent five major vegetation biotypes (Semidesert, Northern Rocky Mountain, Subalpine, Alpine, and Vancouverian). They plan to develop 16 statewide maps, one for each species, showing core habitats (based on a model) connected by least-cost corridors using estimated resistance or movement parameters for each species. These 16 maps will then be joined into a statewide linkage map.

There are advantages to this approach. Most end-users are comfortable with species conservation as a goal, so Natural Landscape Blocks based on species are easy for both scientists and non-scientists to appreciate. Also, agencies have regulatory authority to protect and manage species. Linkages are ultimately intended to serve particular species by allowing for gene flow, demographic rescue, recolonization, and range shift in response to climate change. There is a risk that a linkage based on non-species criteria (e.g., ecological integrity) could fail to include a good linkage for some species. Finally, species-based approaches can be validated using empirical data to determine whether species are actually using them as anticipated.

This approach also has several disadvantages. First, it is difficult to select focal species that represent the entire biota of a state or region. It is also difficult to reliably define each species' core habitat. Once core habitats are mapped for each species, one would have to invent procedures to overlay the many maps (16 in Washington, 24 in Colorado) to produce a coherent set of Natural Landscape Blocks. Finally, having started by defining Natural Landscape Blocks based on species, efforts in Colorado and Washington intend to take the logical "next step," namely using focal species to develop detailed Linkage Designs for each pair of blocks to be connected. In effect, there will be no statewide map until all the individual Linkage Designs are complete. Indeed Washington may decide not to designate Natural Landscape Blocks at all, but instead to develop 16 connectivity maps – one per species – and then attempt to merge these 16 single-species maps into a statewide connectivity map. It is a monumental task to simultaneously work at spatial scales from statewide (or regional) to individual Linkage Designs, and to do all tasks well.

These difficulties dissuaded us from using this approach in this statewide Report for California. Nonetheless, the focal species approach has many advantages, and we hope that Colorado or Washington, or perhaps a regional analysis in California, will provide the first prototype. Because there are no completed examples using multiple species to define Natural Landscape Blocks, we have provided only a few caveats, but no specific guidance, on this approach.

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[29] For a relatively small region (2,500 km^2; 965 mi^2) in northern Italy, Bani et al. (2002) defined core areas for a suite of forest birds and carnivores as areas above a minimum size and minimum number of detections in over 1,000 point counts and transects of the area. They used these cores as start- and end-points for a regional network of corridors. Planners would probably be compelled to use modeled rather than empirical species distributions in larger planning regions within US states.

4.3.2. Determine which Natural Landscape Blocks need to be connected

For a region with 100 Natural Landscape Blocks, there are 4,950 pairs of landscape blocks, and thus 4,950 potential linkages[30]. But each Natural Landscape Block does not necessarily need to connect to every other Natural Landscape Block in the landscape. Therefore scientists and planners must determine which pairs of blocks need to be connected. Simple graph-theoretic procedures such as Delaunay triangulation can identify a set of Natural Landscape Blocks that are the closest neighbors to a given Natural Landscape Block, but these procedures are so mechanical that they will identify neighboring pairs even if they are separated by lands unsuitable for connectivity, such as highly urbanized areas or open water.

Because we could not find any literature to suggest how to identify pairs, we developed a set of rules (Chapter 2) to do so. We refer to this process as drawing "sticks" because we indicated each pair by drawing a straight line (stick) between the centers of the two Natural Landscape Blocks. The stick does not indicate where the connective area lies in map space, but simply indicates the *intent to conserve* connectivity between the Natural Landscape Blocks. We recommend that regional planning efforts use and modify our set of rules to produce results that make sense in the region. Our rules were developed in light of the following overarching motivations:

- Provide enough redundancy that all of the largest Natural Landscape Blocks and well-connected clusters of Natural Landscape Blocks have more than one connection to the larger constellation of Natural Landscape Blocks.
- Avoid drawing a stick that represents a linkage that never existed (e.g., across a major lake or bay) or has been irretrievably lost (e.g., where the only possible connectivity area would have to cross broad swaths of highly urbanized land).
- Minimize unnecessary redundancy, preferentially deleting sticks that represent inferior linkages.
- Never delete a stick that represents a linkage that is currently providing meaningful levels of animal movement, even if connectivity can be achieved by an alternative chain of sticks.

4.3.3. Depict Connectivity Areas on a Map

If a regional effort has sufficient time and money, or if there are only a few "sticks" in the region, we recommend conducting detailed Linkage Designs (see Chapter 5) for all sticks and ignoring the rest of this section. More commonly, limited resources compel planners to use some sort of placeholder to depict connectivity areas on a map, and to develop a few key Linkage Designs at a time. Potential placeholders include:

- *Major riparian corridors*. The major riverine or riparian corridors should be depicted on every regional map, regardless of how connectivity areas are additionally depicted by sticks, arrows, or polygons. Least-cost modeling (and other GIS approaches used, recommended, and discussed in this report) are useful for mapping the needs of terrestrial wildlife, but simply mapping rivers and streams is a more effective and efficient way to map connectivity for fish and other aquatic species.

[30] More generally, for n Natural Landscape Blocks, there are $n*(n-1)/2$ possible pairs of blocks.

- *Centroid-to-centroid sticks* (see above). This choice can be implemented quickly, and we recommend it for depicting each "road fragmentation stick," which represents two landscape blocks separated only by a road, canal, railroad, or similar linear barrier to wildlife. However, we do not recommend using sticks to represent more complex connectivity areas. Because the connectivity area is not mapped, it cannot be described in the way we were able to describe mapped placeholders in this Report (Sections 3.1 and 3.2). More importantly, a "stick map" is not useful as a decision support tool, because a project proponent or permit-granting agency cannot reliably use the stick location to assess whether a project may impact the connectivity area represented by the stick.
- *Hand-drawn arrows or polygons*, from an expert workshop or panel. This approach was used by the earlier California Missing Linkages effort (Penrod et al. 2001) and the Arizona Wildlife Linkage Assessment (Nordhaugen et al. 2006). It is a fast, efficient way to draw on knowledge of many people, including unpublished knowledge. On the other hand, the approach is not repeatable or transparent. It is also subject to over-interpretation because users of the map tend to forget the polygon or arrow is just a placeholder to signal the need for a detailed Linkage Design. If a proposed project does not lie under the arrow or polygon, it is too easy for a project proponent or permit-granting agency to assume the project will not affect the connectivity area.
- *Modeled polygons* like those in this report are produced by transparent and repeatable procedures. If this option is selected, we recommend generating these polygons by least-cost modeling[31]. Least-cost modeling requires one of two types of resistance maps, namely:
    - *Landscape resistance to movement of multiple focal species.* If this option is chosen, the resulting polygon will not be a placeholder, but rather a true Linkage Design. As mentioned in the first paragraph of this subsection, we recommend this option if there are sufficient resources to pursue it, because a full Linkage Design based on the needs of multiple species is superior to a placeholder polygon based on naturalness. Refer to Chapter 5 for guidance on linkage design.
    - *Landscape departure from natural conditions*. This option has the advantage of being quick, and the disadvantage that natural conditions are an imperfect proxy for the needs of multiple species. In this Report, the resistance map was based on landcover (80% of the resistance score, representing today's resistance to wildlife movement) and GAP status (20% of resistance score, representing human commitment not to increase resistance in the future). We modified the landcover map by reclassifying any pixel crossed by a road into a "road" landcover class, and assigned high resistance to pixels in a road

[31] Least-cost modeling is described in detail in Section 5. Instead of least-cost modeling, polygons can be modeled using individual-based movement models, circuit theory, or climate models coupled with a dispersal chain or network flow model. These three competing approaches do provide valuable information about connectivity, but are not yet sufficiently developed to serve as tools for mapping connectivity area. Because these latter three approaches may soon become useful for regional analysis or for linkage design, we describe them in Appendix E.

class. Although resistance scores for landcovers and GAP classes were assigned subjectively, they produced results that seemed reasonable for the landscapes we knew well. We recommend using similar procedures to ours (Chapter 2) because they are simple, repeatable, and easy to understand. A key issue is selecting how broad a swath should be included in the connectivity area. This decision is difficult because least-cost modeling does not allow the analyst to specify a uniform or minimum width, but instead requires the analyst to select the lowest-cost percentage of the landscape, such as the lowest-cost 4% or 6%. In this Report, the most-permeable 5% slice of the landscape produced reasonable connectivity areas, but we recommend experimenting with different percents in several highly divergent linkage areas in each regional landscape. We strongly recommend favoring a relatively large percentage of the landscape. If the regional plan starts with an overly large connectivity area, requires a fine-scale analysis before approving a project that may affect the linkage, and then finds that the Linkage Design is much smaller than the placeholder polygon, no harm has occurred to either the linkage or the project proponent. In contrast, if the regional plan depicts too small a connectivity area, the regional map would be a poor decision support tool.

4.4. Identify a Subset of Most Crucial Connectivity Areas

The steps described up to this point will produce new or different versions of Figures 3.2 through 3.9 in this report, perhaps scaled down to or below the ecoregional level. The main products would be a map of Natural Landscape Blocks (including blocks smaller than recognized at the statewide level), road fragmentation sticks, and placeholder polygons for connectivity areas that are more complex than the road fragmentation sticks. The products should also include supporting documentation, descriptive statistics for each connectivity area, and recommendations for how the map should be used.

Although following the steps outlined above would result in a useful regional product, we recommend that a regional analysis should go two steps further, by identifying a subset of connectivity areas that are most crucial to the ecological integrity of the ecoregion, and using fine-scale analysis (Chapter 5) to replace the placeholder polygons with detailed Linkage Designs in those crucial areas. The South Coast Missing Linkages map (Figure 4.1) is a good example of these additional products. The map conveys the overall vision of regional connectivity in a visually powerful way, and the accompanying Linkage Designs are implementable conservation plans.

In this section, we describe strategies to identify the crucial connectivity areas. Although this is a type of prioritization, we emphatically do not recommend any ranking scheme that would label some connectivity areas as “unimportant.” Instead, the goal is to identify a subset of the connectivity areas whose conservation or restoration would do the most to create a wildland network in the region, *without* ranking individual connectivity areas. Collectively, these crucial connectivity areas create a network of natural areas, such that the value of each linkage depends on maintaining all the others. It would therefore be meaningless to rank

connectivity areas within the crucial group. It would also be counterproductive to assign low importance to one or more connectivity areas outside this group.

The crucial connectivity areas can be identified through one or more of the following procedures:

- *Opinions of end-users*. Given that the end users are actually going to implement the Linkage Designs, their opinions about which linkages to conserve are important. However, the end users typically want some guidance to help them choose wisely. Thus some of the other procedures should probably be used to help inform their opinions.
- *Quantifying biological and physical characteristics* of each connectivity area and its associated Natural Landscape *Blocks*, such as the variables defined in Section 2.4 and reported in *Appendices* B and C. South Coast Missing Linkages (Beier et al. 2006) and the Arizona Wildlife Linkage Assessment (Nordhaugen et al. 2006) weighted each variable and used the weighted sum as a "biological value score" for each linkage. If weights are to be used, we suggest that end-users set weights in a workshop setting, which encourages participants to be consistent and appreciate the priorities of other end users. A critical part of the workshop exercise is a "live" spreadsheet[32] that lets participants see how changes in weights affect the overall score of each linkage. The data table should be populated with values before the workshop, so that workshop participants can focus on the weighting scheme. Several members of the consulting team have participated in weight-setting workshops, and were impressed with the ability of participants to reach consensus in a couple hours of discussion. The only public products of the workshop should be the weighting scheme and the unranked list of most crucial connectivity areas. Final scores for any or all connectivity areas are subject to misinterpretation.
- *Quantifying threats and opportunities* to each connectivity area. Threats and opportunities are more difficult to quantify than physical and biological attributes. We strongly recommend using only variables whose values can be obtained from existing GIS layers (e.g., percent of polygon in a particular landcover or GAP status), an existing database (e.g., a database of projects in the 10-year transportation plan), or a spatially-explicit quantitative model (e.g., an urban growth model, such as developed by Huber 2008). These attributes can be weighted to produce an overall threat and opportunity score. If weighting is to be used, we again recommend that end-users set weights in a workshop. We suggest that each connectivity area be displayed in a 2-dimensional graph, with overall weighted biological score on the x-axis, and overall threat and opportunity score on the y-axis, so that the most crucial areas appear in the upper right of the graph (Beier et al. 2006).

There is no Reliable Connectivity Metric!

None of the attributes listed in Table 2.4 provides an overall metric of how much a connectivity area contributes to statewide or regional connectivity. Using the weighting

[32] See sample spreadsheet at http://corridordesign.org/designing_corridors/pre_modeling/prioritizing_linkages .

schemes described in the previous two paragraphs is one way to try to create a single score, but this composite score is not a direct measure of what each connectivity area is worth. Graph theory (Bunn et al. 2000, Urban and Keitt 2001, Theobald 2006, Minor and Urban 2007, Pascual-Hortal and Saura 2008) provides several metrics that purport to do just that. However, in the opinion and experience of the consulting team, each graph theory metric fails in this regard[33]. For example, Pascual-Hortal and Saura (2006) applied nine metrics to 14 pairs of artificial landscapes created by starting with an original landscape (A) from which connective elements were removed to create a second landscape (B). None of the nine metrics consistently decreased from landscape A to the paired landscape B. Pascual-Hortal and Saura (2006, 2008) offered a new Integral Index of Connectivity (IIC) as a measure that consistently decreased as connectivity was degraded, and they successfully applied it to a conservation planning problem in Spain. However, IIC did not work as a useful metric when the consulting team applied it to the linkages in this Report. We believe it failed because most Natural Landscape Blocks in California, including each of the largest blocks with the highest ecological integrity, had at least two chains of sticks that could connect (directly or indirectly) to almost every other Natural Landscape Block, even ones at the opposite end of the state. Thus removal of any single stick had a trivial impact on statewide connectivity. Southern Rockies Ecosystem Project (2005:20) noted similar results for other connectivity metrics[34]. The good news is that California still has a potentially well-connected network of wildlands. The bad news is that in a well-connected network, no single linkage or handful of linkages stands out as most crucial.

Reflecting on our experience with these metrics, we believe that the most important linkages in a region or state should not be identified by ranking all the linkages individually and then selecting the top 9 or top 19. What is needed is *not* a scoring mechanism for *individual linkages*, but rather a way to identify *which ensemble of linkages* provides the strongest foundation for a regional network. We believe that various ensembles of linkages can best be evaluated by a yet-to-be-invented form of simulated annealing (Section 4.3.1.4), spatially-explicit population models (Carroll et al. 2003), circuit theory (a new type of graph theory – McRae 2006), or a new graph theory metric better suited to complex networks. Until such a scheme is developed, we suggest that end users select among several alternative maps, each depicting one set of top-priority linkages. Tables of descriptors of the Natural Landscape Blocks and connectivity areas should be available to help inform their choices.

4.5. Adaptive Mapping and Planning

Conservation planning, like every other type of planning for linked human-natural systems, is never "done." After a Regional Plan is completed, human activities will split some large natural blocks into two or more smaller blocks, creating new connectivity areas between the

[33] Fundamental graph-theory concepts underlie all GIS raster operations, including least-cost modeling. Graph theory applications can help understand connectivity in many landscapes. Our only point here is that graph theory does not provide a metric that meaningfully states the value of one linkage in a state or large region containing many complexly interconnected Natural Landscape Blocks.

[34] Southern Rockies Ecosystem Project (2005: 29-30) presented a new metric *L*, intended to quantify the importance of each Linkage in a landscape. *L* results from a chain of equations such that the relationships between *L* and tangible traits such as area and distance are not obvious. Future analysis confirming the properties and behavior of *L* may demonstrate its utility.

new blocks. Human activities also might preclude animal movement in some mapped connectivity areas, thus taking them off the map. Not all changes will be for the worse. Indeed, as a result of the Regional Plan, some connectivity areas will be conserved and restored. Protection will be extended to some unprotected areas within Natural Landscape Blocks. Because of all these positive and negative developments, a new set of most crucial connectivity areas will emerge several years after a Regional Plan is completed. Every Regional Plan – just like this statewide effort – will eventually become obsolete.

This obsolescence will require a new round of identifying connectivity areas and new subsets of connectivity areas that would do the most to secure and expand the region's wildland network. Although each effort should acknowledge its own mortality, we do not recommend that each Regional Plan outline the process of its own revision. Many of the data layers and analytic tools used in this report did not exist 15 years ago. New and improved data layers and analytic tools will doubtless be available by the time a Regional Plan needs to be updated.

Revision might be triggered by a new Regional Transportation Plan, revision of land use plans by one or several counties, a new NCCP, or dramatic improvements in data or analytic tools. Regional planning entities should evaluate the regional connectivity analysis when they use it in other plan updates to make sure it is still relevant and adequate. For conservation plans with long time horizons (e.g., 50 years for some NCCPs), planners may need to periodically reevaluate the efficacy of the regional connectivity analysis.

In Chapter 5, we present an approach that is currently available to develop individual Linkage Designs more robust in the face of climate change. As climate modeling becomes more sophisticated and accurate, climate change should be considered in both statewide and regional connectivity maps.

Chapter 5. Framework for Local-scale Analyses

The statewide map of Natural Landscape Blocks and Essential Connectivity Areas can help inform and motivate regional connectivity analyses (Chapter 4), local-scale Linkage Designs (this Chapter), and road improvement plans (Chapter 6). The goal of developing a Linkage Design is to map the specific lands and spell out the specific actions needed to maintain or restore functional connections for species or ecological processes between two or more Natural Landscape Blocks.

In this chapter we provide step-wise procedures for developing Linkage Designs and plans. Except for the relatively new set of instructions related to climate change, each set of instructions provided here has proved useful in local-scale analysis in California and elsewhere over the last six years, and thus represents the state of the science of Linkage Design. However, the science and data sources for modeling landscape connectivity, wildlife habitat, and wildlife movement are evolving rapidly. We note some up-and-coming approaches and procedures in the narrative, in footnotes, and in Appendix E. Our approaches (and the new approaches on the horizon) could be dramatically improved by new GIS data layers, such as high-resolution maps of soil traits or perennial waters reliably and accurately mapped across the spatial extent of an analysis area. In ten years, perhaps sooner, many sections of this chapter will be out of date.

We recommend designing linkages primarily on the basis of focal species (Beier and Loe 1992), following these major steps:

1. *Delineate Natural Landscape Blocks:* Connectivity is meaningful only with reference to the areas to be connected. See Section 4.3.1 for various approaches for delineating blocks.
2. *Engage stakeholders:* The implementers need to be involved from the start (Section 5.2).
3. *Select focal species:* Select focal species from diverse taxonomic groups to represent a diversity of habitat requirements and movement needs (Section 5.3.2).
4. *Map corridors for focal species:* Conduct least-cost corridor analysis for each focal species to identify one or several swaths of habitat that support movement and gene flow of all species (the rest of Section 5.3).
5. *Consider climate change:* Add additional swaths of habitat to increase the utility of the linkage under unknown future climate (Section 5.4).
6. *Evaluate and refine the preliminary Linkage Design:* The most permeable landscape (identified in the previous two steps) may not be very permeable for some species. Therefore planners must analyze the spatial distribution of suitable habitat, especially habitat patches large enough to support breeding, for each species. By evaluating the configuration and extent of potential cores and patches relative to the dispersal ability of focal species, planners can assess whether the preliminary Linkage Design is likely to serve the species, and add habitat to ensure all selected focal species are

accommodated. At this stage, all major rivers and streams should also be added to the Linkage Design unless they are already included in it.

7. *Assess in the field:* Conduct fieldwork to ground-truth existing habitat conditions, document existing barriers and potential passageways, identify restoration opportunities, and consider management options (Section 5.7).
8. *Develop the Linkage Design Action Plan:* Compile results of analyses and fieldwork into a comprehensive report detailing what is required to conserve and improve linkage function, including priority lands for conservation, specific management recommendations, and prescription for mitigating roads and other barriers.

When should a Linkage Design be developed? Ideally, regional Linkage Design efforts such as those in the Central Coast (Thorne et al. 2002), South Coast (Beier et al. 2006), Central Valley (Huber et al. 2010), California Deserts and Bay Area (both Penrod et al. in preparation) will be carried out in each ecoregion in California. However, a few other examples of scenarios that might trigger the development of a Linkage Design are (1) a proposed development project might adversely impact an Essential Connectivity Area; (2) a transportation improvement project is planned in an Essential Connectivity Area, providing an opportunity for improving wildlife movement and habitat connectivity; and (3) a Habitat Conservation Plan, Natural Community Conservation Plan, or Blueprint Plan is being prepared. We caution that a Linkage Design should be based on existing baseline conditions or, as in the case of the Central Valley effort (described in Section 3.3.7) on context and restorability of habitats and *not* on potential future build out scenarios. Basing the analysis on future development scenarios makes it difficult to know what could be achieved for wildlife connectivity. Basing the analysis on existing or restorable conditions provides a biologically optimum plan. Although compromises may occur during implementation, the biological optimum provides a useful reference condition, so that decision-makers can evaluate trade-offs and make good compromises.

Why focal species? Without focal species, we would be designing linkages primarily on the basis of natural landcover, with no way of knowing whether such a connection succeeds in serving biodiversity in any way besides adding some acres of habitat. Focal species also provide a basis for justifying linkage width, which habitats it should include, and the need to include both riparian and upland areas. Future generations of biologists will assess the success of the linkage based on whether it serves the particular species.

5.1. Products of a Linkage Design

A Linkage Design is a detailed action plan for maintaining and improving connectivity that includes:

- Clearly stated goals for the Linkage Design.
- A description of the Natural Landscape Blocks to be served by the linkage, including information on the ecological significance of the connection, vegetation and land-use patterns, and existing conservation investments whose integrity is affected by the linkage.

- An analytic approach that is transparent and repeatable.
- A narrative for each focal species, including justification for selection, distribution and status, habitat associations, spatial patterns, and conceptual basis for species models.
- A narrative describing how climate change was considered in developing the Linkage Design.
- Maps and narratives describing the spatial distribution of habitat in the Linkage Design for each focal species, an assessment of how well the linkage will support movement by each focal species, and spatially-explicit descriptions of impediments to animal movement.
- Prescriptions for maintaining and improving connectivity, such as needs and opportunities for habitat restoration, and recommendations to mitigate the effects of various impediments to connectivity, such as roads, rail lines, in-stream barriers, and urban and rural development.
- Land protection and stewardship opportunities, including existing planning efforts addressing the conservation and use of natural resources in the planning area and other implementation opportunities for agencies, organizations, and individuals interested in helping conserve the connection.
- A description of how the linkage can be incorporated in existing conservation measures (e.g., NCCP, HCP, General Plan open space elements), including statutory or regulatory language relevant to conserving connectivity.

5.2. Stakeholder Engagement

Conserving landscape linkages between natural wildlands usually requires strong collaboration among land management agencies, conservation groups, transportation and resources agencies, sovereign Native American tribes, and many others. Numerous conservation efforts are underway throughout the state, but most have distinct planning jurisdictions too small to conserve ecosystem processes and functions. Involving all relevant agencies and organizations from the inception of the Linkage Design process can promote coordination across jurisdictional boundaries and the partnerships needed to implement the resulting Linkage Design. Participation in a habitat connectivity workshop, to lay the biological foundation for planning in the linkage, can help create momentum and generate enthusiasm for implementation of the resulting plan (Beier et al. 2006). Stakeholders should be given the opportunity to participate in every aspect of the Linkage Design process, including development of the work plan, selection of focal species, review of draft analyses, and roll-out of the final report.

Most stakeholder participation will occur in workshops. The invitation should clearly define the goal of each workshop and explain what it is—and what it is not—to every invitee. Not all stakeholders need or want to attend every workshop. One paragraph can provide enough information to let each person decide whether to attend. If it cannot be stated in a paragraph, the goal is not clearly defined.

Who should be invited to participate? Land management agencies, state and federal wildlife management agencies, conservation non-governmental organizations, transportation agencies, county and municipal planners, local land trusts and conservancies, first nations (Native American tribes), military bases, utility districts, developers, ranchers, universities and other research entities, biological consulting firms, and other potential stakeholders should all be invited. An open door demonstrates that the process is transparent, honest, and inclusive. The plan and its scientific basis are improved by having stakeholders challenge assumptions and offer novel ideas.

5.3. Producing Corridors for Focal Species

Species have been the only focus in almost every published Linkage Design (Beier et al. 2008) and species are the primary focus of the approach we describe here. Additional procedures to make the linkage more robust to climate change (Section 5.4) are desirable, but are still experimental.

5.3.1. Overview and Justification for the Least-Cost Modeling Approach

Here we describe a set of recommended procedures for Linkage Design. Our approach uses least-cost modeling to identify areas best able to support movement between Natural Landscape Blocks for each of several focal species. Our approach also uses patch configuration analysis (Section 5.6) to evaluate how well the design supports movement for these species. Patch configuration analysis is also used to consider the needs of focal species for which a least-cost model is not appropriate.

Least-cost modeling is a GIS technique that models the relative cost for a species to move between Natural Landscape Blocks (more specifically, suitable habitat within each block) based on how each species is affected by various landscape characteristics. The landscape is portrayed in a GIS as a grid of squares; such a grid is called a *raster*, and each square is called a *pixel*. Resistance values are calculated for each pixel in the raster as a function of the input data layer's attributes representing habitat characteristics, such as landcover, topography, and level of human disturbance. *Resistance* refers to the difficulty of moving through a pixel and *cost* is the cumulative resistance incurred in moving from the pixel to targeted endpoints in each Natural Landscape Block. Early examples of least-cost modeling identified a least-cost path—that is, a string of pixels that is only one pixel wide. A pixel-wide path is not a realistic proposal for conservation, so most conservation GIS analysts now identify the lowest-cost *swath* of pixels, which is called a *least-cost corridor*. The least-cost corridor represents the land that best supports species movement between wildland blocks under the model's assumptions (Adriaensen et al. 2003, Beier et al. 2008).

For each focal species, the steps in a least-cost corridor analysis are:

1. Calculate habitat suitability as a function of pixel attributes such as landcover, distance to nearest road, topographic position, and elevation.
2. Use habitat suitability to map patches of breeding habitat.
3. Develop a resistance map (Section 5.3.4). When there are appropriate data on movement of the focal species, calculate resistance as a function of pixel attributes.

Such data are lacking for most species, in which case the inverse of habitat suitability can be used as the resistance map.

4. Select habitat patches within each Natural Landscape Block as targeted end points and calculate cost-weighted distance from each terminus, which calculates a value for every pixel that is the least accumulated cost of traveling from each pixel to the source.
5. Select an appropriate contour (% "slice") to delineate the least-cost corridor.

Individual-based movement models and circuit theory are potential alternatives to least-cost modeling. Both approaches are based on movement needs of focal species, require the same GIS layers, and have the same technical issues as least-cost modeling. In addition, each of these two approaches must overcome unique conceptual or technical hurdles (described in Appendix E) before they can be used to design corridors. Although these alternatives are promising tools for designing corridors in the future, 23 of 24 published corridor or Linkage Designs reviewed by Beier et al. (2008) used least-cost modeling, and none used individual-based movement models or circuit theory[35].

Over the last six years the least-cost modeling procedures described here were used to produce 11 Linkage Designs in California's South Coast Ecoregion (www.scwildlands.org) and 16 Linkage Designs in Arizona (www.corridordesign.org/arizona). They are currently being used to design linkages in the San Francisco Bay Area and in California's Mohave and Sonoran Desert Ecoregions. Beier et al. (2008) outline 16 key analytic decisions that must be made during a Linkage Design based on focal species, and describe some alternatives to the procedures outlined here. This same guidance is repackaged for an audience of GIS analysts and the ecologists at http://corridordesign.org/designing_corridors, which also provides ArcGIS tools for most of the GIS procedures.

5.3.2. Select Focal Species

Each Linkage Design should have multiple focal species, which may include not only mammals but also reptiles, fishes, amphibians, plants, birds, and invertebrates. Lambeck (1997) introduced the focal species concept, and explained how these species can be identified. We recommend inviting biologists from agencies, nongovernmental organizations, universities, tribes, consulting companies, and major landowners to help identify species that would serve as a collective umbrella for all native species and ecological processes. We suggest inviting specialists with local knowledge of each taxonomic group. We recommend that focal species be selected at a workshop, where work can occur within taxonomic sub-groups or as a single group. Selection could also occur by conference call or emailed submissions from individuals. Participants should be provided detailed maps on which they can delineate species occurrences, known or suspected core areas, potential barriers, and areas that need restoration to support movement by nominated focal species. The participant should complete a form for each species nominated, confirming its occurrence in the linkage area, and justifying why it would be useful as a focal species.

[35] The 24th study (Williams et al. 2005) used linked emission scenarios, climate models, climate envelopes, and dispersal chain modeling.

Because large carnivores like bears and mountain lions live at low density and are among the first to be harmed by loss of connectivity, they are appropriate focal species for Linkage Design (Beier 1993; Servheen et al. 2001; Singleton et al. 2002). They also make popular flagship species to increase stakeholder support for linkage conservation. Nonetheless, a linkage should not be designed solely for large carnivores, or any single species. Many species need linkages to maintain genetic diversity and metapopulation stability. Furthermore, most large carnivores are habitat generalists that can move through marginal and degraded habitats, and a corridor designed for them does not serve most habitat specialists with limited mobility (Beier et al. 2009). Indeed, successful implementation of a single-species corridor for large carnivores could have a "negative umbrella effect" if land-use planners and conservation investors become less receptive to subsequent proposals for less charismatic species. The umbrella effect of large carnivores best serves biodiversity if these species are part of a linkage designed for a broad array of native species.

A good suite of focal species would include species in each of several categories; some species may qualify in more than one category:

- *Area-sensitive species:* species with large home ranges or requiring long-distance dispersal for metapopulation persistence (e.g., mountain lion, badger, mule deer, bighorn sheep). These species will be the first to disappear or become ecologically trivial when linkages are severed.
- *Barrier-sensitive species:* species most reluctant to traverse roads, fences, canals, urban areas, and other barriers in the planning area.
- *Less mobile species:* species whose mobility is limited due to extreme habitat specialization, small home range, or short dispersal movements. These species will often be corridor-dwellers (Beier and Loe 1992)—that is, they will require multiple generations to move their genes between Natural Landscape Blocks.
- *Habitat specialists:* one or more species strongly associated with each major vegetation type or topographic element in the linkage area.
- *Species distributed among blocks as a metapopulation*: species requiring dispersal between Natural Landscape Blocks for metapopulation persistence; species requiring connectivity to avoid genetic divergence of a now-continuous population.
- *Ecological indicators:* species tied to an important ecological process, such as predation, pollination, sand transport, or fire regime. A linkage that serves these species is more likely to support ecological interactions and processes.
- *Non-flying migratory populations:* Seasonal migration is crucial for some of California's mule deer populations, and a few other species in California. Although some birds and flying invertebrates also migrate, they typically can fly for tens or hundreds of miles across unsuitable habitat, so their migration is unlikely to be affected by the Linkage Design.

Patch configuration analysis is used for *all* focal species; least-cost modeling is used for *some* focal species. Least-cost modeling is not appropriate for two types of focal species: (1)

Most flying species[36], including most bats, insects, and birds (except perhaps for sedentary species that do not fly long distances between habitat areas, such as gnatcatchers, wrentits, thrashers, quail, or roadrunners). (2) A species that occurs only in the area between wildland blocks but is not a current or historic resident in the Natural Landscape Blocks[37]. Although least-cost modeling is not appropriate for these species, we recommend considering connectivity needs of these species by modeling suitable patches of habitat (Section 5.3.4) and analyzing the configuration of habitat patches (Section 5.6). For each species, a narrative should explain justification for selection, distribution and status, habitat associations, spatial patterns, and the conceptual basis for the model parameters (example narratives at www.scwildlands.org).

We recommend consulting an expert on each focal species, preferably someone with local experience, to parameterize the model and review the results produced by the model. Clevenger et al. (2002) found that expert-based models that did not include a literature review performed significantly worse than literature-based expert models. Therefore, each participating expert should review all papers on habitat selection by the focal species and closely-related species. To parameterize the model, the expert must:

- Assign a *weight* to each habitat *factor* affecting habitat suitability. *Factors* are data layers available in GIS format, such as landcover, elevation, topographic position, and distance to nearest road. The *weight* indicates the relative influence of each factor, such that the weights for all factors sum to 100%.
- For factors that are distributed as continuous variables, such as elevation or distance to road, divide the variable into *classes* (bins) that are meaningful for the species[38]. For instance, if a species occurs only between approximately 1,000 and 2,000 m, the expert might create 5 elevation classes, such as 0-900 m, 900-1,100 m, 1,100-1,900 m, 1,900-2,100 m, and >2,100 m that could be confidently scored.
- Assign a *habitat suitability score* to each class within each factor. For example, within the factor *landcover*, the expert would assign habitat suitability scores for grasslands, scrublands, and juniper woodlands; within the factor elevation, he or she would assign a score to each elevation class. Our procedures require habitat suitability to be scaled from 0 (unsuitable) to 100 (best habitat), with scores of 60 or more indicating habitat suitable for breeding. The expert should be advised to assign a score of 0 only if the elevation class, landcover, distance to road class, or topographic position is absolutely unsuitable for the species.
- Estimate *minimum patch size*, i.e., the smallest area needed to support breeding by the species.
- Estimate *longest documented dispersal distance*, that is, the longest distance an

[36] Highly mobile flying species do not move in pixel-to-pixel fashion, as assumed by least-cost modeling. In the future, new approaches may model movement of such species in a meaningful way.

[37] Beier et al. (2006) discuss other, relatively uncommon conditions in which least-cost modeling is not appropriate.

[38] One could develop an equation that relates habitat suitability to the pixel's elevation, but it is typically easier and more appropriate to divide elevation into classes. Consider for example, how difficult it would be for a species expert to devise an equation to represent the highly non-linear response of a species to elevation in this example.

individual of the species has been documented to move from its birthplace to the place where it becomes a breeding adult. The expert should provide citations for this information, or indicate that it is based on unpublished data. If there are no data for the species, the expert can make inferences from closely related species, or species of similar body size, mobility, and natural history.

5.3.3. Compile and Refine Digital Data Layers

Habitat models are based on factors such as landcover, topography, and roads, not because these fully describe habitat, but because these are usually the only relevant factors available as GIS layers. Therefore models are incomplete to the extent that they exclude important factors that are not mapped across the entire analysis area. Models are also inaccurate because landcover—the most important factor in most models—is typically mapped with only 60%-80% accuracy (Yang et al. 2001)[39]. Nonetheless, models are a transparent way to organize what we do know about each species, and thus are useful.

The GIS layers needed for permeability analyses include digital elevation models, roads, and landcover[40]. Each GIS data layer should be compiled at the resolution of the finest GIS layer, typically a 30 x 30-m cell. The source, type, scale, accuracy (if known), and date of each data layer should be reported. Road and vegetation layers should be compared to recent high-resolution aerial photos and manually updated to reflect recent changes. GIS layers of land ownership types, protected lands, and species occurrences are also helpful to display and interpret outputs. Additional spatial data layers such as maps of soil properties or locations of water sources may be useful for some focal species, but in most analysis area these attributes are not mapped reliably at high resolution throughout the area.

Topographic position and slope are variables derived from a digital elevation model. The topographic position index (Jenness 2006) categorizes each pixel into one of four topographic positions (canyon bottoms, ridgelines, flats, or slopes) based on the pixel elevation and slope. Topographic position is important because some species are known to be associated with canyon bottoms, steep slopes, or other topographic positions. Elevation can be used as a factor if the species is known to occur within a certain range of elevation.

The road layer consists of lines, from which the analyst must derive either road density or distance to roads. Many least-cost models use road density within a moving window around the focal pixel (e.g., kilometers of paved road per square kilometer) as a variable. Unfortunately, despite the seeming scale-invariance of length per length-squared, the calculated value of road density changes non-intuitively with the size of the moving window, making it difficult to estimate resistance for road density classes (D. Majka and P. Beier, unpublished data). Furthermore, published estimates of animal occurrence with respect to road density cannot be translated to a different moving window size. Therefore we

[39] Vegetation for a portion of the state has been mapped at a fine scale (1-2 acre minimum mapping unit) at a level of accuracy well above 80% (http://www.dfg.ca.gov/biogeodata/vegcamp/). Direction for expanding and standardizing this spatial data within CDFG also comes from AB2785.

[40] Other layers can and should be used, especially if they allow the model to be improved with empirical data on habitat use or movement. However, many empirical studies and habitat models rely on variables that are not available in GIS format.

recommend using distance to nearest road as the road-related variable. Scientific reports using this metric can be directly imported into the model.

5.3.4. Developing Maps of Resistance and Habitat Patches

Ideally, resistance to ecological flows should be empirically measured from movements of focal species or estimates of gene flow rates across various landscape features (e.g., cover types, roads[41], topographic features). Advances in use of GPS tracking devices and genetic analyses may provide empirical estimates of resistance of landscape features to ecological flows. Currently, however, there is virtually no scientific literature estimating resistance, so almost all least-cost models therefore assume that resistance is linearly related to habitat suitability. For example, if habitat suitability for a focal species is scored 0 to 100, resistance could be scored as 100 minus suitability or the reciprocal of suitability. A slightly simpler approach, which we use here, is to scale suitability such that zero indicates the highest suitability, and larger values[42] indicate progressively more unsuitable habitat. Although our approach follows the common practice of assuming resistance is linearly related to habitat suitability, we recommend using empirical estimates of resistance when they are available.

Habitat suitability values are calculated separately for each focal species, because a given attribute (e.g., percent forest cover) does not affect each species in the same way. The weighted arithmetic mean is the most commonly used algorithm to combine weights, but the weighted geometric (multiplicative) mean better reflects a situation in which one habitat factor limits suitability in a way that cannot be compensated by other factors. For instance, if a species is never found above 2,000 m, a pixel at 2,500 m should be considered unsuitable even if landcover, distance from road, and topographic position are optimal. Therefore, we suggest using a weighted geometric (multiplicative) mean to combine the influence of the various factors:

$$\text{Suitability} = (S_A \wedge W_A) * (S_B \wedge W_B) * (S_C \wedge W_C),$$

where S_A, S_B, and S_C are suitability ratings for the pixel's particular class within factors A, B, and C, respectively, and W_A, W_B, and W_C are the factor weights. The weighted geometric mean is strongly influenced by suitability scores of zero or near zero, such that if a score for any class is 0, then suitability of the pixel remains 0 regardless of other factor weights or scores.

The next procedure is to define *habitat patches* to be used a start and end points of least-cost corridor models, as modeled patches of low resistance in the least-cost model, and as meaningful descriptors in patch configuration analysis (Section 5.6). A habitat patch is a cluster of pixels that are good enough (mean score above 60 [or other threshold set in Section

[41] We discourage the practice of assigning low resistance to road pixels that contain an existing or proposed crossing structure. Such a practice forces the modeled corridor through the crossing structure, even if it is located in poor habitat, and thus prevents the analyst from identifying the best locations for crossing structures.

[42] In most of our work, we created a scale for suitability (and resistance) that ranges from 0 to 25 or 0 to 100. As mentioned in Section 2.3.1, we suggest that the upper bound should be about 1,000 times the lower bound to enable the analyst to model situations with extremely high resistance to ecological flows. Extremely high values should be reserved for the few features that, on the basis of strong empirical evidence, are almost totally impermeable to the focal species or process.

5.3.2]) and big enough (i.e., larger than the *minimum patch size* specified by the species expert) to support breeding.

5.3.5. Least-cost Corridor Modeling

Running the least-cost model requires specifying the endpoints that are to be connected. Rather than simply using the targeted Natural Landscape Blocks as terminuses, we recommend using habitat patches within the Natural Landscape Blocks. If the two Natural Landscape Blocks are irregularly shaped such that the facing edges nearly touch at one point but are elsewhere much farther apart, the least-cost model will tend to run through the narrowest gap, even if habitat there is much less suitable than a longer, less direct path. In these situations, to give the model "room to run" and "find" the more appropriate least-cost corridor, we recommend drawing parallel lines within the Natural Landscape Blocks and selecting patches behind these lines as target endpoints for the analysis.

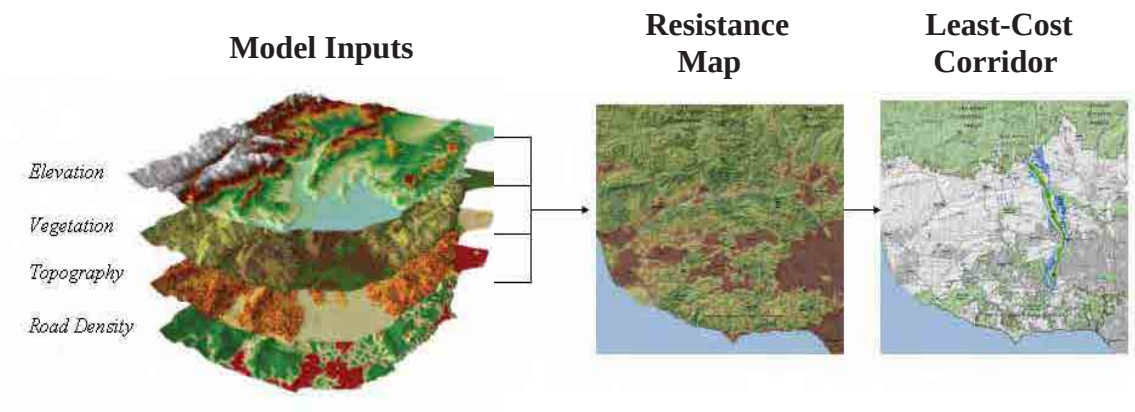

Figure 5.1. Resistance (usually the inverse of habitat suitability) is a function of elevation, vegetation, topography, and a road-related variable. The swath of pixels with the lowest cost (cumulative resistance from each terminus) is the least cost corridor.

To model the needs of corridor dwellers (species that require several generations to move through the corridor) the least-cost model may produce better results if the analyst assigns all pixels within *habitat patches* a resistance value near zero. We recommend this procedure when modeling a species with a few habitat patches embedded in a matrix dominated by poor habitat. In such situations the procedure tends to produce a corridor that links those patches in stepping-stone fashion. Nevertheless, if the habitat quality in a large fraction of the matrix is near the threshold between suitable and unsuitable, a slight decrease in the threshold can cause most of the matrix to be mapped as a habitat patch, resulting in a highly linear corridor that fails to include the highest-quality habitat. In these situations we discourage use of this procedure unless the analyst is confident that the threshold is precisely known.

Once the targeted endpoints are identified, the analyst calculates the cost-weighted distance (cumulative resistance) from each terminus and then sums the two raster outputs to produce the corridor result. The analyst then selects a "slice" (% cost contour) of the corridor output to delineate the least-cost corridor. A key decision is how to select a slice that is wide enough for the species. For a corridor dweller, one suggestion is that the least-cost corridor should be as wide as the species' typical home range. However, if the focal species is

strongly territorial, this could result in corridors fully occupied by home ranges where social interactions impede movement through the corridor. Therefore we suggest that minimum width for a corridor dweller should be considerably more than one home range width along all or most of the length of the corridor. Passage species able to move through the least-cost corridor in one or several days can doubtless pass through areas narrower than their typical home range, thus consideration of the biology of the focal species should be used to recommend a reasonable minimum width.

5.4. Producing Corridors to Support Movement During Climate Change

Climate change has arrived in California. During the past century, the earth's temperatures have warmed faster than at any other time within the past 650,000 years, and the western United States are warming faster than the rest of the nation. Moser et al. (2009) describe how climate change is already occurring in California: Since 1920, California's annual nighttime temperatures have increased 0.33 °F per decade, daytime temperatures have increased 0.1 °F per decade, and sea levels along California's coast have risen seven inches. Although irrigation has reduced the expected warming from climate change in the Central Valley, the amount of water available for irrigation is expected to decline because Sierra snowpack is melting earlier in the spring season. As irrigation decreases, warming in the Central Valley will accelerate. California wildfires have increased in frequency, duration, and size. In the future, increasing frequency of extreme sea-level events may threaten Delta levees and the Bay-Delta ecosystem, and may increase the risk of saltwater intrusion into coastal aquifers. The future will almost certainly bring increased winter rainfall (and less snow), earlier spring runoff, and increased frequency of extreme storm events. In the context of Linkage Design, the most important finding is that the geographic ranges of many of California's plants and animals are shifting northward and toward higher elevations. For example, the western edge of the ponderosa pine forest in the Sierra Nevada moved 4.4 miles eastward and shifted upward by about 637 feet, with the previously ponderosa-dominant areas being replaced by oaks and other trees (Thorne et al. 2006).

Adaptation to climate change is necessary. Even under the most optimistic scenarios of emissions and carbon sequestration programs, past emissions will drive temperature and precipitation changes for at least 50 years (IPCC 2001). These changes will cause range shifts by plants and animals and reassembly of biotic communities (Lovejoy and Hannah 2005). Three adaptation strategies may improve the ability of organisms to respond to change. First, conserving or increasing genetic diversity can help species adapt evolutionarily to new temperature and precipitation regimes (Skelly et al. 2007; Millar et al. 2007). Second, managers can translocate species to areas expected to have suitable future climate (McLachlan et al. 2007; Hunter 2007). Third, managers can support range shifts by enlarging protected areas or linking them with corridors (Hannah et al. 2002).

Enhancing connectivity is an essential adaptation strategy. This strategy avoids over-reliance on evolutionary response or the artificiality of assisted colonization. It is also consistent with paleoecological evidence that extensive shifts in "species' geographical ranges have been the most important response of biota to past large, rapid climatic changes" (Huntley 2005:121). Lovejoy and Hannah (2005), Hannah and Hansen (2005), Heller and

Zavaleta (2009), and other major reviews conclude that enhancing connectivity and linking natural landscapes is the single most important adaptation strategy to conserve biodiversity during climate change. Sadly, only three studies (Williams et al. 2005, Rouget et al. 2006, Phillips et al. 2008) designed linkages expressly to conserve movement during climate change. All other Linkage Designs have been designed for focal species, using models for which landcover was the dominant driving factor. Because landcover will change over the next 100 years, each of these designs is potentially at risk of failing to fully provide functional connectivity in the face of climate change.

5.4.1. Overview and Justification of the Land Facet Approach

In light of these considerations, and strongly-expressed concerns from the Multidisciplinary Team at the initial meeting for this Project, we provide procedures to design corridors and linkages that should provide connectivity during climate change and during future periods of climate quasi-equilibrium. Our procedures define corridors of physical landscape features; these corridors are combined with the focal species corridors (Section 5.3) to produce a Linkage Design (Sections 5.5 and 5.6). Thus the new corridors complement, rather than replace, focal species corridors[43].

The land facet approach is still under development. Paul Beier, Brian Brost, and Jeff Jenness at Northern Arizona University have used land facets to create Linkage Designs for three essential connectivity areas in Arizona. In spring 2010, they will submit a more detailed "cookbook," targeted at linkage designers, to a peer-reviewed journal and will release free ArcGIS 9.3 tools at www.corridordesign.org. We emphasize that the land facet approach is not as well-developed as least-cost modeling. With the enormous recent attention to climate change, new and better approaches may emerge within a few years. We strongly urge analysts to look for alternatives, and to consider the land facet approach one reasonable way to address this crucial issue. This approach is subject to much less uncertainty than the only alternative proposed so far, uses data layers already assembled for focal species modeling, and is cheap in terms of computing time. Before describing the land facet approach, we briefly discuss what appears to be a more direct and obvious approach.

Why not design linkages by modeling climate change and species response to climate change? Two efforts have done this, namely Williams et al. (2005) and Phillips et al. (2008). They conducted complex analyses in which an emission scenario drove a global model of air and ocean circulation. The circulation model was downscaled to predict future climate at a finer regional scale (2.9-km^2 cells). Climate envelope models were then used to produce dynamic maps of the expected future distribution of biomes or species to map a corridor that would support range shift by focal species (in this case, plants in the family Protaceae). Unfortunately, each step has enormous uncertainty. For example, total emissions during 2000-2100 vary by a factor of six among the six major emission scenarios[44] (IPCC 2001).

[43] As previously stated, the Essential Connectivity Areas in this report are intended to be replaced by detailed designs based on focal species and land facets (or another climate change approach). Although climate change will affect the *character* of California's natural landscapes, these landscapes will be in approximately the same *locations* as the Natural Landscape Blocks in this report, and thus it makes sense to design linkages to connect them. We expect the typical linkage design will be mostly within the Essential Connectivity area because it represents a large fraction of the most natural land between Natural Landscape Blocks.

[44] The models of Williams et al. (2005) and Phillips et al. (2008) used only one emission scenario.

Worse yet, during the first six years of the century, actual emissions exceeded *all* of these scenarios (Raupach et al. 2007). For a single emission scenario, the seven air-ocean global circulation models[45] produce markedly different climate projections (Raper and Giorgi 2005; IPCC 2001). Finally, climate-envelope models may perform no better than chance (Beale et al. 2008). Because these sophisticated models have not been able to simulate the large shifts that paleoecologists have documented during the last 100,000 years of glacial oscillations, Overpeck et al. (2005:99) concluded that the "lesson for conservationists is not to put too much faith in simulations of future regional climate change" in designing robust conservation strategies. Finally, the resolution of the final maps (pixel sizes in square kilometers) is coarser than the typical scale at which lands are targeted for conservation. Although this modeling approach ingeniously and directly simulates the actual processes of emission, climate change, and species response, it is not yet a useful tool to help design a linkage between two Natural Landscape Blocks.

So what is a good alternative? Wessels et al. (1999) coined the term *land facets* for *recurring areas of relatively uniform topographic and soil attributes*. Hunter et al. (1988:380) suggested that conservation planners should protect areas with optimal diversity of such landscape units: "we advocate basing the coarse-filter approach on physical environments as 'arenas' of biological activity, rather than on communities, the temporary occupants of those arenas." The idea is rooted in the life zone concept of C. Hart Merriam (1890), who observed that plant and animal communities were predictably associated with particular combinations of latitude, elevation, and aspect. The idea is also rooted in the "state factor model of ecosystems," which holds that the species present at any given site are a function of climate, other organisms present in or adjacent to the site, disturbance regime, topography, the underlying geological material, and time (Jenny 1941; Amundson and Jenny 1997). Land facets reflect the stable state factors, namely topography, geology, and time (geology and time represented by a single soil-related variable). Other state factors—climate, interspecific interactions, dispersal, and disturbance regimes—are subject to change under a warming climate and are thus less reliable for conservation planning. Protecting diverse physical environments may also ensure the persistence of the ecological and evolutionary processes that maintain and generate biodiversity (Cowling et al. 1999, Noss 2001, Moritz 2002, Cowling et al. 2003, Rouget et al. 2006, Pressey et al. 2007, Klein et al. 2009). Thus, a linkage that includes strands of each land facet should support species movements in any future climate regime, and a linkage that includes a strand with high diversity of land facets should support species movements during periods of climate instability. Beier and Brost (2010) present the conceptual basis of the land facet approach in detail, and discuss a few of the key issues in applying the approach to Linkage Design.

A land facet Linkage Design looks a lot like a focal species Linkage Design. Like linkages designed for multiple focal species, linkages designed for a diversity of land facets (Figure 5.2) contain multiple strands. Specifically the Linkage Design for land facets includes:

- Several (typically 5-15) corridors, each of which is designed to maximize continuity of one of the major land facets that occurs in the planning area. Each such strand or

[45] The models of Williams et al. (2005) and Phillips et al. (2008) used only one air-ocean global circulation model, which was downscaled using one of several possible regional circulation models.

corridor is intended to support occupancy and between-block movement by species associated with that land facet in periods of climate quasi-equilibrium. Like each focal species corridor, each land facet corridor is produced by least-cost modeling.

- One corridor with high beta diversity (i.e., high local interspersion of facets; Figure 5.2) to support range shift, species turnover, and other ecological processes relying on interaction between species and environments. The high diversity corridor is also produced by least-cost modeling.
- A riverine strand to support aquatic species, nutrient and sediment flows, and upland-wetland interactions. Although such a corridor could be produced by an automated GIS procedure, hand-drawing the major riverine connection is easier.

Can the land facet approach be used in analyses of regional or statewide connectivity? It took many person-hours to develop procedures that produce repeatable, interpretable results at the level of one Essential Connectivity Area. With additional work, a land facet approach probably could be developed for other scales.

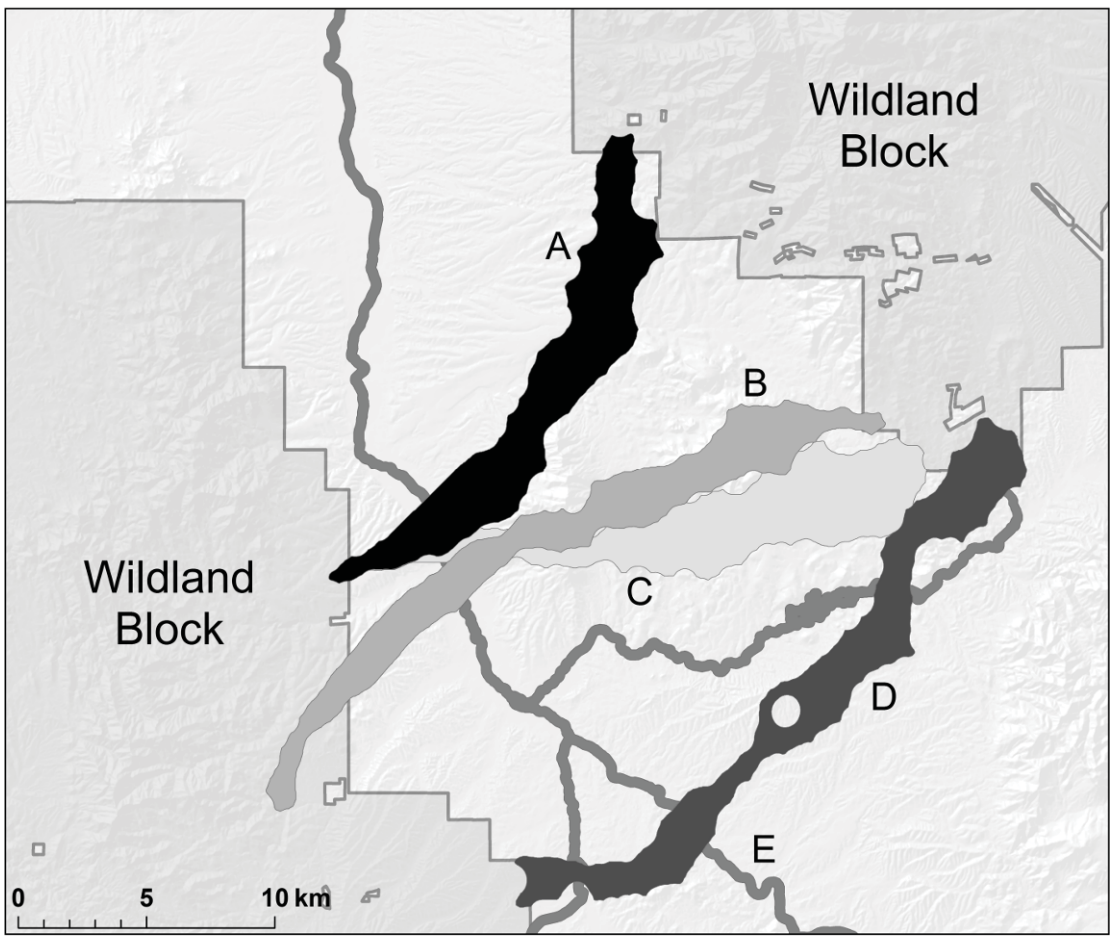

Figure 5.2. A multistranded linkage of land facets designed to allow species to shift their ranges in response to climate change and to support movement during periods of quasi-equilibrium. Area A optimizes continuity for high local diversity of land facets. Other areas provide the best continuity of high-insolation, steep slopes (area B), low-elevation, gentle canyons (area C), and low-elevation,

gentle ridges (area D). Area E encompasses the region's main river and its only perennial tributaries from each wildland block.

5.4.2. Defining and Mapping Land Facets

Ideally soil attributes should be used along with topographic attributes to define land facets. Unfortunately, soil maps have many limitations (Sanchez et al. 2009). For instance, polygons may lack values for a certain attribute or contain several states of that attribute, indicating the presence of unmapped heterogeneity. In most nonagricultural parts of the western United States, soil maps consist of large, heterogeneous polygons from which inferences about relevant traits, such as moisture, texture, depth, or soil nutrients, cannot be made (Beier and Brost 2010). Therefore, in this description of the approach, land facets are based only on topographic variables. Because the approach can use both categorical and continuous variables, it can readily be adapted to accommodate categorical soil variables (such as soil type) and continuous soil variables (such as soil depth or moisture). We strongly encourage use of relevant soil data if they are available throughout a planning area.

Moore et al. (1991) and Franklin (1995) discuss approximately 20 topographic variables that can be derived from a digital elevation model (DEM). To maintain easily interpretable and biologically meaningful land facets, Beier and Brost (2010) recommend using four variables to define land facets from 30-m digital elevation model:

1. Topographic position: Each pixel is assigned to one of three classes, namely canyon, ridges, and slopes (including flat slopes), by comparing the elevation of the pixel to the average elevation within a 200-m radius (Jenness 2006).
2. Annual solar insolation: Sum of instantaneous radiation at half-hour intervals for one day per month over a calendar year using the 'Solar Radiation' tool in ArcGIS 9.3 (ESRI, Redlands, California). The tool calculates half-hour radiation as a function of latitude, aspect, slope, and topographic shading, but ignores thickness of atmosphere and cloud cover.
3. Steepness, expressed as percent slope.
4. Elevation.

To ensure that the classification represents the land facets of the Natural Landscape Blocks, Beier and Brost (2010) recommend using only pixels inside the blocks to define the land facets. Later, pixels in the rest of the rest of the analysis area will be assigned to appropriate land facets. Using only the pixels inside the Natural Landscape Blocks, the procedures (www.corridordesign.org) start with these two steps:

1. Assign each pixel into broad classes of the categorical variable topographic position. This classifies each pixel as a ridge, canyon, or slope pixel. The procedure allows other categorical variables, such as soil type, but the default is topographic position.

2. Characterize each slope pixel based on all three continuous variables (steepness, elevation, insolation). Characterize each ridge or canyon pixel based only on steepness and elevation[46].

Within each topographic position, the procedures involve the following sequential steps:

1. Identify outliers[47], i.e., cells with combinations of values of the continuous variables that rarely occur in the Natural Landscape Blocks, and remove them from the analysis. These cells often occur in isolated patches and are limited to a small portion of the landscape. Outliers produce clusters that span a large fraction attribute space, with a diffuse or diluted ecological interpretation. Extreme cells also shift the position of the cluster centroid to a sparse region of multivariate space.
2. Use multivariate procedures to classify the pixels into *c* natural clusters or groups, for each value of *c* from 1 to 10. For instance, a three-way split of ridges might include high elevation-steep, low elevation-steep, and low elevation-gentle classes. Beier and Brost (2010) explain why fuzzy *c*-means cluster analysis (Dimitriadou et al. 2009) is superior to hierarchical cluster analysis, nonmetric multidimensional scaling, and two-step cluster analysis.
3. Identify the number of classes, *c*, that best corresponds to the natural multivariate "lumpiness" in the continuous variables. This step requires examining several goodness of fit metrics, evaluating interpretability of classes, draping maps of facet polygons over a topographic hillshade, plotting facet centroids in multivariate space, and inspection of the proposed class map by someone familiar with the landscape to assess whether the *c* clusters correspond to natural units or impose artificially discrete categories on a continuous landscape.
4. Use a confusion matrix to identify poorly classified pixels, such as slope pixels that assign with roughly equal probability to the "warm, steep, high elevation" and the "cold, steep, high elevation" classes. Remove poorly classified pixels from the analysis to produce a set of distinctive land facets.

These procedures will typically produce a set of 8-16 land facets, such as "high elevation, steep ridges" and "low elevation, gentle, hot, slopes."

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[46] Insolation is not used to identify subclasses of ridges or canyons, because ridges and canyons are usually symmetrical features, that is, a high-insolation ridge is almost always close to a low-insolation ridge. A classification that used insolation to define land facets within ridges would identify different land facets for their opposing sides, such as north-facing and south-facing ridgelines, despite their otherwise similarity. This unnecessarily complicates corridor design because the opposing sides of canyons and ridges are generally close in proximity and can be treated as a unit for conservation purposes. In developing these procedures in real landscapes, Brost and Beier (unpublished data) found that splitting ridges and canyons on insolation always produced redundant corridors, such as a "cold, high elevation, steep ridge" corridor that was completely intertwined with a "hot, high elevation, steep ridge" corridor.

[47] By default the procedure (kernel density estimation) identifies the most extreme 10% as outliers, but the user can over-ride this setting. Because outliers are defined relative to cells inside Natural Landscape Blocks, the proportion of cells in the matrix classed as outliers will differ from 10% or other specified value.

5.4.3. Developing Maps of Resistance

In focal species approaches to designing linkages, the resistance of a cell represents the difficulty of movement through that cell for a focal species. For the land facet approach, the resistance of a cell is based on the departure of that cell from the prototypical cell of the focal land facet. In particular, we recommend using Mahalanobis distance as the resistance metric. Mahalanobis distance can be thought of as the number of "multivariate standard deviations" between the attributes of a pixel and the ideal values for the focal land facet type. For each land facet type, the procedures include the following steps:

- Calculate Mahalanobis distance for every pixel in the analysis area, using the following ideal values:
    - Mean elevation of pixels in the focal land facet within the Natural Landscape Blocks.
    - Mean insolation of pixels in the focal land facet within the Natural Landscape Blocks.
    - Mean steepness of pixels in the focal land facet within the Natural Landscape Blocks.
    - 100% of pixels in a 100-m radius of the focal facet type.
- Use aerial photographs (if GIS land-cover layers are not up-to-date) to digitize urban or developed areas such as mines that are unlikely to support wildlife movement, even if they otherwise are of a focal facet type. Assign "no data" resistance values (equivalent to infinite resistance) to these pixels. This prevents a corridor from being identified through areas unlikely to support species movements. We caution against wholesale exclusion of agricultural areas, especially if they can be restored to natural vegetation or occupy a large portion of the most productive land facets (those with gentle slopes and high soil moisture).

In addition to linkage for individual land facets, we recommend designing a single linkage with maximum interspersion of land facets. To do so, our procedures produce a resistance map as follows:

- Calculate Shannon's diversity index, H', of land facets in a 5-pixel radius (McCune and Grace 2002). Shannon's index incorporates richness and evenness into a single measure. Thus, a high index is achieved by not only maximizing the number of land facets within the neighborhood, but also balancing representation of those facets.
- Calculate resistance of a pixel as $1/(H' + 0.1)$. This formula[48] assigns low resistance to pixels with a high diversity index.
- As in designing linkages for individual land facets, remove areas unsuitable for connectivity from the resistance surface.

[48] Adding 0.1 precludes undefined values which would occur in the unlikely event that all cells in a neighborhood are outliers.

5.4.4. Least-cost Corridor Modeling

The procedures to produce a least-cost corridor for each land facet type are very similar to those used to develop least-cost corridors for focal species:

- Define corridor termini (potential start and end points) as areas within the wildland blocks that contained the most occurrences of the focal land facet[49].
- Calculate the cost-weighted distance (cumulative resistance) from each terminus and sum the two resulting raster outputs to produce the corridor results.
- Select a "slice" (cost contour) of the corridor output to delineate the least-cost corridor. We suggest selecting the slice with an approximate minimum width of 1 km over its length for corridors < 10 km long, increasing to an approximate minimum width of 2 km for much longer corridors. We chose these minima because they are similar to the widths that typically resulted from the analyses for focal species.

To produce a single corridor with maximum interspersion of land facets, our procedures use the following steps:

- To define corridor termini, follow these steps within each Natural Landscape Block separately:
  - Identify the half[50] of all cells inside each Natural Landscape Blocks with the highest H' values and aggregate them into polygons.
  - Retain the largest 50% of the polygons as termini[51].
- Calculate the cost-weighted distance (cumulative resistance) from each terminus and sum the two resulting raster outputs to produce the corridor results.
- Select a "slice" (cost contour) of the corridor output that is approximately 1 km to 2 km wide, as for the least-cost corridors for individual land facets.

Rivers and ephemeral drainages span elevation gradients in a way that increases interspersion and promotes ecological processes and flows, such as movement of animals, sediment, water, and nutrients. Because mechanical geospatial algorithms may fail to identify important riverine connections that are obvious to a human expert, we recommend manual inclusion of riverine elements if necessary (e.g., Cowling et al. 1999, 2003).

5.5. Joining the Corridors for Focal Species and Land Facets into a Preliminary Linkage Design

The preliminary linkage design is the simple union of all the least-cost corridors described in Sections 5.3 and 5.4, namely the least-cost corridors for all focal species, all land facets, the land facet diversity corridor, and the major riverine or riparian corridors. The biological

[49] By default, the procedure aggregates all cells with at least one occurrence of the facet within a 3-cell radius into polygons, and retains the largest 50% of these polygons in each respective wildland block as termini. The user can over-ride these settings. In three Arizona landscapes, the largest polygons produced by these settings always contained a high density of the focal facet type.
[50] The user can select a different threshold.
[51] The user can select a different percentage.

significance of the union can best be described as the zone within which the modeled species would encounter the least energy expenditure and the most favorable habitat as they move between targeted protected areas, and which should best support species movement during climate change and during future periods of relative climate stability. The output does not consider dispersal limitations of the focal species (Section 5.6) or identify barriers to movement (Section 5.7). Rather, it identifies the best zone available for focal species movement based on the data layers used in the analyses.

How much overlap is likely to occur between the corridors for focal species and the corridors for land facets? B. Brost and P. Beier (Northern Arizona University, unpublished data) have developed Linkage Designs based on land facets for three landscapes in Arizona. Linkage Designs for focal species had previously been released for each landscape (www.corridordesign.org/arizona). The union of land facet corridors was about 28% larger than the union of focal species corridors, and performed as well as or better than the union of species corridors in providing connectivity for 25 of 28 focal species-landscape combinations[52]. In contrast, the union of focal species provided excellent connectivity for only 24 of 35 land facets. By slightly expanding the land facet linkage design to accommodate the three poorly-served species, a blended design was able to serve all focal species and all land facets in an area about 29% larger than the focal species design.

5.6. Using Patch Configuration Analysis, Adding Streams and Rivers, and Imposing a Minimum Linkage Width to Create the Final Linkage Design

Although the least-cost union identifies the best zone available for movement based on the data layers used in the permeability analyses, it does not address whether suitable habitat in the union occurs in large enough patches to support viable populations and whether these patches are close enough together to allow for inter-patch dispersal for species that require multiple generations to traverse the linkage. For such species, the linkage must support a collection of breeding patches separated by distances within the dispersal range of the species, such that movement and gene flow can occur in steppingstone fashion over several generations.

Patch configuration analysis starts by overlaying habitat patches (Section 5.3.4) on a map of the least-cost union, and then comparing distances between habitat patches to the maximum dispersal distance of the species. Because most methods used to document dispersal distance underestimate the true value (LaHaye et al. 2001, Beier et al. 2006), we recommend estimating the maximum dispersal distance as twice the *longest documented dispersal distance* (Section 5.3.2). This assumption is conservative in the sense that it would assign importance to habitat patches that may appear to be isolated based on documented dispersal distances. In our experience, most breeding patches are captured by the preliminary Linkage Design. Species-specific habitat patches should be added to the linkage if the addition would reduce the need for individuals to move distances longer than the estimated dispersal capability of the focal species. A species expert should be consulted to determine if the

[52] There were 21 different focal species, but several occurred in > 1 landscape, such that there were 28 combinations of focal species and landscapes.

preliminary Linkage Design captured enough of these habitat patches to serve the species or if additional patches should be added to ensure that the Linkage Design provides sufficient live-in or "move-through" habitat for the species' needs.

At this point in the analysis, if the linkage design does not include the major riverine or riparian connections between Natural Landscape Blocks, these rivers and streams should be manually added to the linkage design. Simply including rivers and streams is more efficient than least-cost modeling to map connectivity for fish and other aquatic species

Chokepoints in the Linkage Design may prevent organisms from moving through the linkage. To ensure that functional processes are protected, a minimum width should be imposed for all portions of a final Linkage Design. The minimum should be wide enough to provide live-in habitat for species with dispersal distances shorter than the linkage. Harrison (1992) proposed a minimum corridor width for a species living in a linkage as the width of one individual's territory (assuming territory width is half its length). Thus, a minimum corridor width of 1 km would accommodate home ranges of up to about 2 km^2, which is larger than home ranges of most reptiles, amphibians, and small mammals. To serve larger species such as mountain lion, mule deer and badger, minimize edge effects (Environmental Law Institute 2003), and reduce the risk that territorial behavior of medium-sized animals might impede movement (Section 5.3.5), we recommend a minimum width of 2 km (1.2 mi). Beier et al. (2008) provide additional rationale for broad minimum widths.

For a variety of species, including those not formally modeled, a wide linkage helps ensure availability of appropriate habitat, host plants (e.g., for butterflies), pollinators, and areas with low predation risk. In addition, fires and floods are part of the natural disturbance regime in many ecoregions and a wide linkage allows for a semblance of these natural disturbances to operate with minimal constraints from adjacent urban areas. A wide linkage should also enhance the ability of the biota to respond to climate change, and buffer against edge effects.

5.7. Assess Linkage Design in the Field

After the analyses are completed, fieldwork should be conducted in the Linkage Design to ground-truth existing habitat conditions, document existing barriers and potential passageways, and identify restoration opportunities and management prescriptions. Because major roads, railroads, and canals usually present the most formidable potential barriers, such features that transect the linkage design should be evaluated[53]. This would include characterizing existing structures, such as bridges or culverts that may accommodate road crossings by wildlife. Although most such structures were initially built to accommodate streamflow, research and monitoring have confirmed that these structures can facilitate wildlife movement. Therefore, all existing structures (e.g., bridge, underpass, overpass, culvert, pipe) should be photo documented and the following data collected: shape; height,

[53] Natural barriers, such as rivers, may impede movement by some species. There is virtually no research on interventions to mitigate natural barriers, because ecologists respect natural barriers as a part of the evolutionary landscape. Nonetheless, if human development has destroyed historical areas that once provided upland connectivity for such species, it may be appropriate to consider steps to mitigate natural barriers.

width, and length of the passageway; floor type (metal, dirt, concrete, natural); passageway construction (concrete, metal, other); visibility to other side; light level; fencing that acts as a barrier or funnel to wildlife movement; and vegetative cover within and near the passageway. Field biologists should also record their impression of current and potential levels of animal movement at all potential choke-points.

There may be no existing structures in the lowest-cost area of the Linkage Design. In such cases wildlife may be crossing a road at grade, or may not be crossing at all. Careful evaluation of these areas for wildlife trails or other diagnostic signs can help to identify areas where crossing structures should be installed. Canals or aqueducts may also be potential barriers to wildlife movement in a linkage but a vegetated landbridge, at least 300 feet wide may restore wildlife movement. Each important location should be recorded with a Global Positioning System (GPS) device. Data on existing structures should be presented in a map and table.

The analyst should compare these data on existing conditions to guidelines in Chapter 6, and the Wildlife Crossings Guidance Manual (Meese et al. 2009). This comparison will suggest whether permeability is sufficient for wildlife movement. If not, the plan should include prescriptions to upgrade existing structures and add new ones.

Field biologists should also identify other habitat restoration needs and opportunities, such as removing barriers to stream flow or removing large patches of invasive plants. Existing urban and rural development, mining operations, wind turbines, and recreational activity centers that may impede the utility of the linkage should be described and geo-referenced.

5.8. Linkage Design Action Plan

Implementing a Linkage Design will likely require collaboration among county planners, land and resource management agencies, transportation agencies, conservancies, non-governmental organizations and private landowners. The Linkage Design Action Plan should provide detailed documentation, descriptions, and strategies related to the Linkage Design map. It should help conserve the connection by providing detailed descriptions of existing barriers within the linkage and recommended actions to improve linkage function.

The plan should also provide a description of how the linkage can be incorporated in existing conservation measures (e.g., NCCP, HCP, General Plan open space elements) and identify existing planning efforts addressing the conservation and use of natural resources in the planning area and other implementation opportunities for agencies, organizations, and individuals interested in helping conserve the connection. For example, the plan can be used as a resource for regional land managers to guide how they can best help sustain biodiversity and ecosystem processes by implementing the Linkage Design. Relevant aspects of the plan can be folded into management plans of agencies and organizations administering conservation lands in the vicinity of the Linkage Design. Transportation agencies can use the plan to design new projects and find opportunities to upgrade existing structures. Regulatory agencies can use this information to help inform decisions regarding impacts on streams and other habitats. The plan can also help motivate and inform construction of wildlife crossings,

watershed planning, habitat restoration, conservation easements, zoning, land acquisition, and the siting of conservation and mitigation banks.

Public education and outreach are vital to implementation of a Linkage Design—both to change land use activities that threaten wildlife movement and to generate appreciation for the importance of the linkage and the wildland blocks the Linkage Design will help sustain. The biological information, maps, figures, tables, and photographs in the plan should be materials ready for interpretive programs. Public education can encourage residents at the urban-wildland interface to become active stewards of the land and generate a sense of place and ownership for local habitats and processes. Such voluntary cooperation is essential to preserving linkage function.

Chapter 6. Framework for Considering Roads in Natural Landscape Blocks and Essential Habitat Connectivity Areas

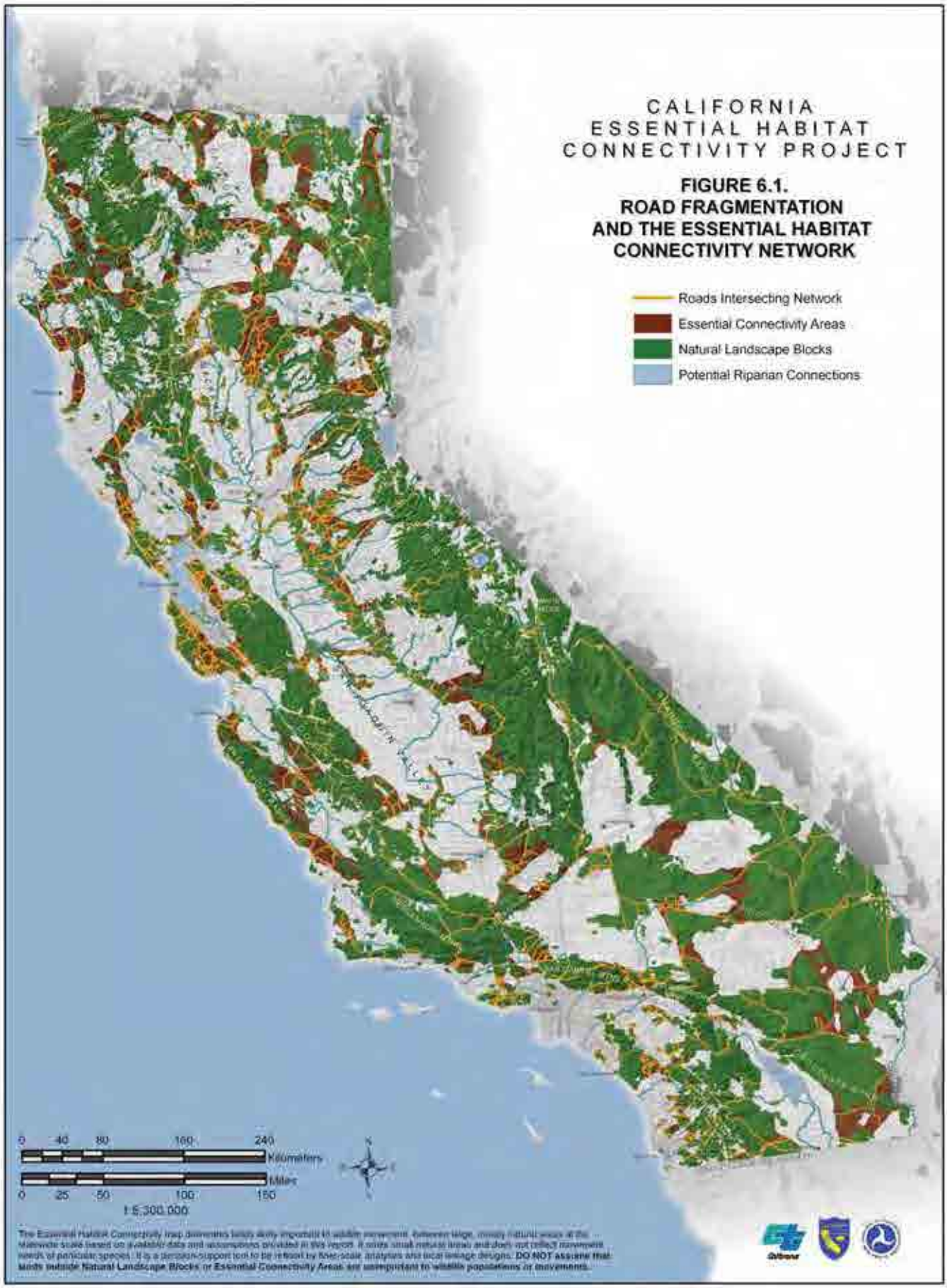
The Essential Habitat Connectivity Map can be used as a resource to guide more detailed efforts to address the fragmenting affects of roads, perform regional connectivity analyses, and design local-scale linkages. This chapter provides (1) a framework for how to evaluate existing or planned roads in Natural Landscape Blocks or Essential Connectivity Areas, (2) guidance to help avoid, minimize, and mitigate the impacts of roads on connectivity, and (3) guidance on enhancement projects to make existing or new roads more permeable. This section is relevant to all paved roads, not just highways. We focus especially on crossing structures, which can be highly effective measures for enhancement and mitigation.

Chapter 3 includes maps of 850 Natural Landscape Blocks in California, and 744 pairs of neighboring Natural Landscape Blocks for which connectivity should be conserved and enhanced (excluding 31 linkages from a Natural Landscape Block in California to a Natural Landscape Block outside California). Of these, 552 pairs of Natural Landscape Blocks were separated only by a road, with no significant fragmentation by urbanization, intensive agriculture, or other land uses that remove natural landcover (Figure 6.1). In these cases, mitigating the impacts of roads is the primary action needed to maintain or restore connectivity.

Road fragmentation is also important in the 192 Essential Connectivity Areas delineated using least-cost modeling. Of these, 66% (127 ECAs) are crossed by major roads, and 92% (177 ECAs) are crossed by secondary highways. Overall, major or secondary highways occur in 96% of Essential Connectivity Areas. Smaller paved roads probably occur in all Essential Connectivity Areas. Because roads can act as filters or barriers to wildlife movement and other ecological flows (Forman et al. 2003), mitigating their impacts is an important strategy for enhancing connectivity in nearly all Essential Connectivity Areas[54].

Arizona provides an example of how a statewide connectivity map can inform road planning. Arizona Department of Transportation, Arizona Game and Fish Department, and Federal Highways Administration were key funders and developers of the 2006 Arizona Wildlife Linkage Assessment. Immediately after the plan was developed, detailed Linkage Designs were completed in 16 priority Essential Connectivity Areas. Furthermore the agencies committed to the highest level of mitigation for roads that crossed protected Natural Landscape Blocks (even in the absence of a linkage design). As a result, the agencies are now implementing several dramatic mitigation and enhancement measures. For instance, two wildlife overpasses are being constructed in 2010, primarily for bighorn sheep, as part of

[54] Note that this chapter focuses on roads as barriers to wildlife movement. However, several other types of linear infrastructure, such as rail, water conveyance, etc. may also impact wildlife corridors and should be evaluated and then avoided, minimized, and mitigated as appropriate. Some methodology presented in this Chapter may also be suitable for these other types of linear infrastructure.


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
FIGURE 6.1.
ROAD FRAGMENTATION
AND THE ESSENTIAL HABITAT
CONNECTIVITY NETWORK
Roads Intersecting Network
Essential Connectivity Areas
Natural Landscape Blocks
Potential Riparian Connections
0 40 80 160 240
Kilometers
0 25 50 100 150
Miles
1:5,300,000
The Essential Habitat Connectivity map delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale based on available data and assumptions provided in this report. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analysis and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

mitigation for the realignment of US-93 between Kingman, Arizona, and Las Vegas, Nevada. In December 2009, Pima County, Arizona, committed bond dollars to build a wildlife overpass across State Route 77 between the Tortolita and Santa Catalina Mountains near Tucson. Within five years, Arizona Department of Transportation will build overpasses, primarily for pronghorn, on State Route 64 and US-89 north of Flagstaff.

6.1. Impact of Roads on Connectivity

The physical footprint of the nearly 4 million miles of roads in the United States is considerable[55], and the *ecological* footprint of the road network extends much farther (Forman et al. 2003). Direct effects of roads include road mortality, habitat fragmentation and loss, and reduced connectivity. The severity of these effects depends on the ecological characteristics of a given species (Table 6.1). Direct roadkill affects most species, with severe documented impacts on wide-ranging predators such as the cougar in southern California, the Florida panther, the ocelot, the gray wolf, and the Iberian lynx (Forman et al. 2003). In a 4-year study of 15,000 km of road observations in Organ Pipe Cactus National Monument, Rosen and Lowe (1994) found an average of at least 22.5 snakes per km per year killed due to vehicle collisions. Roads cause habitat fragmentation because they break large habitat areas into smaller habitat patches that support fewer individuals, which can increase loss of genetic diversity and risk of local extinction. Additionally, roads may prevent access to essential physical or biological features necessary for breeding, feeding, or sheltering.

In addition to these obvious effects, noise from traffic or road construction may alter habitat use and activity patterns, increase stress, reduce reproductive success, and increase predation risk for terrestrial vertebrates (Bowles 1995, Larkin et al. 1996). Roads also increase the spread of exotic plants and animals, promote erosion, create barriers to fish, and pollute water sources with roadway chemicals (Forman et al. 2003). Recent studies demonstrate that vehicles deposit 300 to 800 exotic seeds per square meter per year to roadside areas, often from several kilometers away (von der Lippe and Kowarik 2007). Highway lighting also has important adverse impacts on animals (Rich and Longcore 2006).

Table 6.1. The ecological effects of roads vary with species traits.

	Effect of roads		
Characteristics making a species vulnerable to road effects (from Forman et al. 2003)	**Road mortality**	**Habitat loss**	**Reduced connectivity**
Attraction to road habitat	★		
High intrinsic mobility	★		
Habitat generalist	★		
Multiple-resource needs	★		★
Large area requirement/low density	★	★	★
Low reproductive rate	★	★	★
Behavioral avoidance of roads			★

[55] A single freeway (typical width = 50 m, including median and shoulder) crossing diagonally across a 1-mile section of land results in the loss of 4.4% of habitat area for any species that cannot live in the right-of-way.

6.2. Where to Mitigate or Enhance

The environmental effect analysis for any substantial highway project should consider habitat fragmentation, loss of habitat connectivity, effects on designated critical habitats, and direct or indirect effects to wild animals and plants (Forman and Alexander 1998), as well as dangers to humans due to vehicle-wildlife collisions. Meese et al. (2009) provide guidance on data collection and impact assessment to help evaluate where avoidance, minimization, enhancement or mitigation for Caltrans' road projects should occur.

This Report provides additional information, namely maps Natural Landscape Blocks and Essential Connectivity Areas (Chapter 3), a framework to identify additional blocks and connectivity areas (Chapter 4), and a framework to produce detailed Linkage Designs (Chapter 5). These mapped polygons should help inform decisions in planning and project delivery about where to mitigate and what level of investment is required (Table 6.2). In locations where a road crosses a Natural Landscape Block in protected status, the strongest enhancement and mitigation measures should be used. Protected status represents a significant public investment and commitment to ecological integrity, and roads should not compromise that investment. In contrast, it may or may not be appropriate to fully mitigate an existing or proposed road across an unprotected Natural Landscape Block, depending on land ownership and intended future land use. In such cases, the impact analysis should consider the fact that the area is a Natural Landscape Block, and make an informed decision whether to mitigate to the level appropriate for a protected Natural Landscape Block.

Table 6.2. For major road projects (new road or road alignment, adding a lane, building a new interchange, constructing or renovating a bridge or culvert), appropriate mitigation depends on the location of the project and an evaluation of its effects. Analysis of impacts would occur for all projects; the table suggests additional actions or analysis appropriate for effects occurring in important connectivity areas.

	Protection Status	
Project Location	**Protected[a]**	**Not Protected**
Within Natural Landscape Block	Mitigate to highest standards (Section 6.3) throughout the area. When modifying existing roads, seek opportunities to *enhance* wildlife movement.	Impact analysis should consider NLB designation.
Within Essential Connectivity Area	Conduct local-scale analysis (Chapter 5) and replace ECA with a Linkage Design.	
Within Linkage Design	Mitigate to standards suggested by the Linkage Design in locations suggested by the Linkage Design. When modifying existing roads, seek opportunities to *enhance* wildlife movement.	
Outside NLB, ECA, or Linkage Design	This Report adds no special considerations[b].	

[a] Protected lands (GAP status 1, 2, or 3) include all lands in which natural landcover is protected from conversion to human land uses throughout most of the area, even though some extractive uses such as logging, grazing, or mining may occur in parts of the area. Protected lands include private lands protected by easements.
[b] Analysis of impacts should occur for these projects, because they may affect movement of locally-important wildlife.

Specific guidance on where to locate crossing structures or other measures to minimize effects of roads on wildlife movement can come from one of two sources:

- Field data such as road kill, wildlife tracks or trails, locations of radio-tagged animals, or repeated observations of wildlife (Meese et al. 2009). These data are most useful when they provide evidence of wildlife crossing—i.e., mitigations should occur in the areas with greatest wildlife movement. However we caution that lack of evidence of wildlife movement cannot be interpreted as lack of need for crossing structures or other mitigations, for two reasons:
    - Because many roads were built without considering wildlife movement, the lack of movement today is no indication of levels of movement that will occur after transportation-related projects to enhance wildlife movement. For example, elk and other wildlife crossed SR-260 in central Arizona much more often two years after a two-lane road was replaced by a four-lane divided road that included crossing structures integrated with roadside fencing (Dodd et al. 2007b).
    - It takes a large effort to detect rare movements, and rare movements can be critical to population survival (Beier 1993). For example, adjacent to the Santa Ana Mountains in southern California, Morrison and Boyce (2009) reported that none of three radio-tagged mountain lions attempted to cross SR-91 and I-15. Beier (1995) had earlier tagged 32 mountain lions in the Santa Ana Mountains and documented several successful crossings of both highways.
- Modeled wildlife corridors, such as those produced during the process of Linkage Design (Chapter 5). Ideally, these models should be parameterized using field data collected in or near the linkage area.

6.3. Avoidance and Mitigation Measures for Roads

The Wildlife Crossings Guidance Manual (Meese et al. 2009) provides detailed guidance, specific to particular groups of wildlife, regarding crossing structures, fencing, median barriers, signs, lighting, speed bumps, vegetation management, animal detection systems, and animal escape devices. The Wildlife Crossings Guidance Manual addresses both modification of existing highways and design of new roads. Clevenger and Huijser (2009) provide thorough, well-illustrated technical guidelines for the planning, design and evaluation of wildlife crossing structures and associated fencing and gates to facilitate road-crossing for particular species and species groups in different landscapes. The Wildlife and Roads website of the Transportation Research Board (http://www.wildlifeandroads.org/) offers a decision tree for transportation planners and examples of successful mitigations, and provides links to other helpful documents and websites. In this section, we draw on these documents and other literature to provide general guidance for enhancing wildlife connectivity across roads.

Avoidance of new roads in Essential Connectivity Areas and Natural Landscape Blocks is more effective than mitigation as a strategy to conserve connectivity. However, where roads already exist, or where there are proposals to build or expand roads within Essential Connectivity Areas or Natural Landscape Blocks, wildlife crossing structures, integrated with roadside fencing, can facilitate wildlife movement across roads. These structures include

wildlife overpasses, underpasses, bridges, and culverts. Although many of these structures were not originally constructed with ecological connectivity in mind, many species benefit from them (Clevenger et al. 2001; Forman et al. 2003). No single crossing structure will allow all species to cross a road. For example rodents prefer to use small culverts, while bighorn sheep prefer vegetated overpasses or open terrain below high bridges. A concrete box culvert may be readily accepted by a mountain lion or bear, but not by a deer or bighorn sheep (Clevenger and Waltho 2005). Small mammals, such as deer mice and voles, prefer small culverts to wildlife overpasses (McDonald and St Clair 2004). Some mammals avoid crossing two-lane roads, even when traffic is as low as 100 vehicles per day (McGregor et al. 2008); thus crossing structures may be needed even on lightly-used small roads.

Wildlife overpasses are most often designed to improve opportunities for large mammals to cross busy highways. As of 2003, about 50 overpasses had been built in the world. Only six of these are in North America (Forman et al. 2003), but these numbers are increasing dramatically (for example the five overpasses underway and planned in Arizona, as noted in the introduction to this Chapter). Overpasses are typically 30 to 50 m wide, but can be as wide as 200 m. Overpasses are readily used by large mammals in Europe (van Wieren and Worm 2001). In Banff National Park, Alberta, grizzly bears, wolves, bighorn sheep, deer, elk, and moose prefer overpasses to underpasses, while species such as mountain lions prefer underpasses (Clevenger and Waltho 2005).

Wildlife underpasses include viaducts, bridges, culverts, and pipes, and are often designed to ensure adequate drainage beneath highways. Bridged crossing structures (where the road is supported on piers or abutments above a watercourse) differ from culverts (a round or rectangular tube under a road) in several ways. The most important difference is that the streambed under a bridge is mostly native rock and soil (instead of concrete or corrugated metal in a culvert) and the area under the bridge is large enough that a semblance of a natural stream channel returns a few years after construction. Even when rip-rap or other scour protection is installed to protect bridge piers or abutments, stream morphology and hydrology usually return to near-natural conditions in bridged streams, and vegetation often grows under bridges. In contrast, vegetation does not grow inside a culvert, and hydrology and stream morphology are permanently altered not only within the culvert, but for some distance upstream and downstream from it.

Bridged underpasses are best for deer and other animals that prefer open crossing structures, and tall, wide bridges are best. Mule deer in southern California avoid small underpasses, and only use underpasses under large spanning bridges (Ng et al. 2004). The average size of underpasses used by white-tailed deer in Pennsylvania was 15 ft (4.6 m) wide by 8 ft (2.4 m) high (Brudin 2003). Because most small mammals, amphibians, reptiles, and insects need vegetative cover for security, bridged undercrossings should extend to uplands beyond the scour zone of the stream, and should be high enough to allow enough light for vegetation to grow underneath. In the Netherlands, rows of stumps or branches under crossing structures increased connectivity for smaller species crossing floodplains under bridges (Forman et al. 2003). Black bear and mountain lion prefer less-open structures (Clevenger and Waltho 2005).

Culverts, if well-designed and located, can be an excellent way to mitigate the effects of roads for small and medium sized mammals (Clevenger et al. 2001; McDonald and St Clair 2004). Pipe culverts and concrete box culverts are used by many species, including mice, shrews, foxes, rabbits, armadillos, river otters, opossums, raccoons, ground squirrels, skunks, coyotes, bobcats, mountain lions, black bear, great blue heron, long-tailed weasel, amphibians, lizards, snakes, and southern leopard frogs (Yanes et al. 1995, Brudin 2003, Dodd et al. 2004, Ng et al. 2004). Black bear and mountain lion prefer less open structures; large culverts can provide connectivity for these species (Clevenger and Waltho 2005). In south Texas, bobcats often used 1.85-m x 1.85-m box culverts to cross highways, preferred structures near suitable scrub habitat, and sometimes used culverts to rest and avoid high temperatures (Cain et al. 2003).

Culvert usage can be enhanced by providing a natural substrate bottom, and in locations where the floor of a culvert is persistently covered with water, a ledge established above water level can provide terrestrial species with a dry path through the structure (Cain et al. 2003). It is important that both ends of the culvert be flush with the surrounding terrain so that animals can easily enter and exit. When culverts are built solely to accommodate peak flows, the upper ends are often partway up the fill slope, far above the natural stream bottom, and the lower ends either have a concrete pour-off of 8-12 inches (20 cm – 30 cm) or develop a pour-off lip due to scouring action of water. A pour-off of several inches makes it unlikely that many small mammals, snakes, and amphibians will find or use the culvert.

Based on the increasing number of scientific studies on wildlife use of highway crossing structures, we offer these guidelines for crossing structures intended to facilitate wildlife passage across roads and railroads. These recommendations also apply to canals (Peris and Morales 2004, Rautenstrauch and Krausman 1989).

1. **Multiple types of crossing structures should be constructed and maintained to provide connectivity for all species likely to use a given area** (Little 2003). Different species prefer different types of structures (Clevenger et al. 2001; McDonald and St Clair 2004; Clevenger and Waltho 2005; Mata et al. 2005). For deer or other ungulates, an open structure such as a bridge is crucial. For medium-sized mammals, black bear, and mountain lions, large box culverts with natural earthen substrate flooring are optimal (Evink 2002). For small mammals, pipe culverts with a diameter between 1 and 3 feet (0.3 and 0.9 meters) are preferable (Clevenger et al. 2001; McDonald and St Clair 2004).

2. **Crossing structures should be spaced based on home range size of species to be accommodated**. Because most reptiles, small mammals, and amphibians have small home ranges, metal or cement box culverts should be installed at intervals of 150-300 m (Clevenger et al. 2001). For ungulates (deer, pronghorn, bighorn) and large carnivores, larger crossing structures such as bridges, viaducts, or overpasses should be located no more than 1.5 km apart (Mata et al. 2005; Clevenger and Wierzchowski 2006). Inadequate size and insufficient number of crossings are the two primary causes of poor use by wildlife (Ruediger 2001).

3. **Suitable habitat for species should occur on both sides of the crossing structure** (Ruediger 2001; Barnum 2003; Cain et al. 2003; Ng et al. 2004). This guideline applies to both local and landscape scales. On a local scale, vegetative cover should be present near entrances to give animals security, and reduce negative effects of lighting and noise (Clevenger et al. 2001; McDonald and St Clair 2004). A lack of suitable habitat adjacent to culverts originally built for hydrologic function may prevent their use as potential wildlife crossing structures (Cain et al. 2003). On the landscape scale, "crossing structures will only be as effective as the land and resource management strategies around them" (Clevenger et al. 2005). Suitable habitat must be present throughout the linkage for animals to use a crossing structure.

4. **Whenever possible, suitable habitat should occur *within* the crossing structure.** This recommendation can best be achieved by having a bridge high enough to allow sufficient light for vegetation to grow under the bridge, and by making sure that the bridge spans some upland habitat that is not regularly scoured by floods. Where this is not possible, rows of stumps or branches under large span bridges can provide cover for smaller animals such as reptiles, amphibians, rodents, and invertebrates, although regular maintenance is required to replace artificial cover removed by floods. Within culverts, mammals and reptiles prefer earthen to concrete or metal floors.

5. **Structures should be monitored for, and cleared of, obstructions such as detritus or silt blockages that impede movement.** Small mammals, carnivores, and reptiles avoid crossing structures with significant detritus blockages (Yanes et al. 1995; Cain et al. 2003; Dodd et al. 2004). In southern California and Arizona, over half of box culverts less than 8 x 8 ft (2.4 m x 2.4 m) have large accumulations of branches, Russian thistle, sand, or garbage that impede animal movement (Beier, personal observation). Bridged undercrossings rarely have similar problems.

6. **Fencing should keep animals off the road and direct them towards crossing structures, and should never block entrances to crossing structures** (Yanes et al. 1995, Gagnon et al. 2007). In Florida, construction of a barrier wall to guide animals into a culvert system resulted in 93.5% reduction in roadkill, and also increased the total number of species using the culvert from 28 to 42 (Dodd et al. 2004). Fences, guard rails, and embankments at least 2 m high discourage animals from crossing roads (Barnum 2003; Cain et al. 2003; Malo et al. 2004). One-way ramps on roadside fencing can allow an animal to escape if it is trapped on a road (Forman et al. 2003). In areas where bridges or causeways pass through shorebird habitat, fencing or metal poles 9 to 14 feet tall (height of tallest vehicles expected) on both sides of the bridge can reduce shorebird mortality by about two thirds (A. Bard, Florida Department of Environmental Protection[56]).

[56] http://www.fhwa.dot.gov/environment/wildlifeprotection/index.cfm?fuseaction=home.viewArticle&articleID=5
A similar design by K. Price and K. Lee (Caltrans) and S. Brown (US FWS) is being planned for the Schuyler Heim bridge in Los Angeles.

7. **Raised sections of road discourage animals from crossing roads, and should be used when possible to encourage animals to use crossing structures**. Clevenger et al. (2003) found that vertebrates were 93% less susceptible to road-kills on sections of road raised on embankments, compared to road segments at the natural grade of the surrounding terrain.

8. **Manage human activity near each crossing structure**. Clevenger and Waltho (2000) suggest that human use of crossing structures should be restricted and foot trails relocated away from structures intended for wildlife movement. However, a large crossing structure (viaduct or long, high bridge) should be able to accommodate both recreational and wildlife use. Furthermore, if recreational users are educated to maintain utility of the structure for wildlife, they can be allies in conserving wildlife corridors. At a minimum, nighttime human use of crossing structures should be restricted.

9. **Design crossing structures specifically to provide for animal movement**. Because traffic noise within an undercrossing can discourage passage by wildlife, new, quieter designs are needed to minimize vehicle noise in underpasses (Gagnon et al. 2007). Ungulates prefer undercrossings with sloped earthen sides to vertical concrete sides (Dodd et al. 2007). High openness ratio (height x width divided by length) promote animal travel. Perhaps the best way to achieve this open ratio is to minimize the distance an animal must travel within the structure (Dodd et al. 2007). Most culverts are designed to carry water under a road and minimize erosion hazard to the road. Culvert designs adequate for transporting water often have pour-offs at the downstream ends that prevent wildlife usage. At least one culvert every 150-300 m of road should have both upstream and downstream openings flush with the surrounding terrain, and with native landcover up to both culvert openings, as noted above.

10. **Consider climate change in the design of crossing structures.** Climate change is expected to increase total global precipitation, but precipitation will increase greatly in some areas and will be unchanged, or even decrease, in other locations. During the last century in California, extreme storm events have become more frequent, and some wildlife species have shifted their geographic ranges northward and upward in elevation (Moritz et al. 2008, Moser et al. 2009). These trends are likely to accelerate in the future (Moser et al. 2009). Future changes in land use (such as potential abandonment of agricultural land), complex interactions of precipitation and temperature, and future interactions among species will result in range shifts that are not simple movements northward and higher in elevation (Halpin 1997, Peterson et al. 2005). These trends have implications for design of crossing structures. Perhaps most important, crossing structures should be built to accommodate flows exceeding historic floods. In addition, bridge spans should be long enough to span some upland habitat that will not be scoured by future floods. Finally, crossing structures to accommodate large mammals should be built even in Essential Connectivity Areas where large mammals do not occur today but historically occurred or are projected to occur in the future.

Chapter 7. Strategies for Integrating and Institutionalizing the California Essential Habitat Connectivity Project

7.1. The Collective Mission to Conserve Connectivity

Maintaining and enhancing functional ecological connectivity across California's landscape in the face of human development and climate change is no easy task, and no single agency or small group of agencies can tackle it alone: Collaboration and coordination are key. The Multidisciplinary Team for the California Essential Habitat Connectivity Project was therefore purposely diverse—with 62 local, regional, state, federal, and tribal agencies, comprising over 200 members, asked to serve as ambassadors for connectivity within and outside their agencies.

Each agency invited to join the Multidisciplinary Team has a unique role to play in conserving ecological connectivity while also pursuing its own mission—whether it involves improving transportation, delivering water and power, providing recreational opportunities, or conserving biological diversity. For example, infrastructure planning agencies—such as the California Department of Transportation and California Department of Water Resources—have stewardship goals to protect and enhance California's ecological resources while serving the needs of California's growing population. Wildlife agencies—such as the U.S. Fish and Wildlife Service, U.S. National Marine Fisheries Service, and California Department of Fish and Game—actively plan for conservation of biodiversity and rare species, while also serving as regulators and land managers. Land-management agencies—like the National Park Service, U.S. Forest Service, U.S. Bureau of Land Management, and California State Parks—seek to maintain functional ecological connectivity to meet their charge of managing our public lands for natural resource values and recreational and other opportunities. The objectives of numerous other resource agencies—such as the California Energy Commission, California Department of Forestry and Fire Protection, and U.S. Bureau of Reclamation—can also benefit from and contribute to ecological connectivity in some capacity, despite their widely different missions. Finally, local and regional planning agencies—such as city and county planning departments or regional councils of governments—try to improve the conservation of open space and natural resources within their jurisdictions by incorporating and helping implement wildlife movement and habitat connectivity plans. Thus, while each of these agencies has its own unique mission, there are commonalities, and connectivity conservation fits all of them to some degree.

Likewise many hundreds of non-governmental non-profit organizations throughout the state have missions dedicated to land conservation, habitat restoration, endangered species protection, environmental planning, environmental advocacy, etc. that are focused or tangential to conserving ecological connectivity. Additionally, many universities are contributing research and knowledge towards increasing habitat connectivity. These organizations have served a critical role in conserving California's diverse landscapes and

maintaining and enhancing ecological connectivity, working both on their own and in partnership with public agencies. These non-governmental organizations and universities will continue to serve a key role in helping to implement a statewide network of wildlands that provides functional ecological connectivity across the California landscape.

One key to successful connectivity conservation is to capitalize on opportunities for inter-agency collaboration, such as Natural Community Conservation Plans, Habitat Conservation Plans, Regional Blueprint Plans, watershed plans, or non-governmental organization (NGO) guided regional linkage plans (such as the South Coast Missing Linkages, Bay Area Critical Linkages, and California Desert Connectivity Projects). The Essential Habitat Connectivity Project was designed to support such collaborative planning efforts. It is hoped that the data and strategies generated by the California Essential Habitat Connectivity Project will facilitate coordinated efforts to conserve connectivity. The data itself will be available to any interested agency or organization, as described in Chapter 8. Below, we present strategies for incorporating this analysis into conservation and planning programs at several spatial scales on the California landscape. The programs that are listed below are only a small sample of the many conservation and planning programs occurring at the regional, statewide, and local levels. Many other existing agencies and programs at a variety of spatial scales may want to incorporate this information into their plans and activities. Likewise, private landowners may want to use this information to understand how they can be a part of a regional conservation goal or engage in the discussion.

7.2. Collaborative Conservation Programs: Planning and Funding Opportunities for Connectivity

This section describes a variety of existing conservation programs, plans, and regulations whose continued implementation could both benefit, and benefit from, the products of the Essential Habitat Connectivity Project. These programs cover a wide array of spatial scales—from western North America to the State of California to various regions or local areas within the state.

7.2.1. Connectivity Conservation for the Western United States

Western Governors' Association. In 2008, the Western Governors' Association established the Western Governors' Wildlife Council (WGWC), a group of representatives from 19 western states. The mission of the Western Governors' Wildlife Council, consistent with Western Governors' Association Resolution 07-01, is to identify key wildlife corridors and crucial wildlife habitats in the west, and coordinate implementation of needed policy options and tools for preserving those landscapes. A draft white paper (Western Governors' Association 2009) calls for standardization of data and definitions so connectivity analyses can be performed across state boundaries. California is actively participating in the Western Governors' Wildlife Council to help with this standardization, so that its Essential Habitat Connectivity Map and other biological data sets will be available and useful to bordering states for achieving connectivity conservation at the broadest possible scale. We also expect that these data will help California to define its "Wildlife Sensitivity Areas," an analysis each state is completing for the Western Governors' Association.

Western Regional Partnership. The Western Regional Partnership is a senior policy level partnership among the Department of Defense, other federal agencies, and state and tribal executive leadership in the states of Arizona, California, Nevada, New Mexico, and Utah. The Western Regional Partnership has established a Wildlife Corridors, Critical Habitat, and Threatened and Endangered Species Committee, with the goal of sharing best practices for addressing preservation, maintenance, and restoration of wildlife corridors and crucial habitats. California's Essential Habitat Connectivity Map will likely be used in this Committee's pilot project in the Mojave Desert Region. The Western Regional Partnership highlights such pilot projects to attract federal funding for conserving connectivity.

Landscape Conservation Cooperatives. The U.S. Fish and Wildlife Service has initiated the Landscape Conservation Cooperatives Program, which is a national framework composed of 22 geographic areas that collectively will comprise a seamless national network of landscapes capable of sustaining abundant, diverse, and healthy populations of fish, wildlife, and plants (http://www.fws.gov/science/shc/lcc.html). The program was initiated in 2009 to emphasize strategic conservation on a landscape scale through the development of self-directed conservation-science partnerships between the U.S. Fish and Wildlife Service, U.S. Geological Survey, and other federal agencies, states, tribes, non-governmental organizations, universities, and stakeholders within a geographically defined area. California is part of four Landscape Conservation Cooperatives, which include North Pacific (North Coast Ecoregion in California, and all habitats west of the Cascade crest in Oregon and Washington, and extending into coastal habitats of Southeast Alaska), Great Basin (Modoc Plateau and the Eastern Sierra Nevada and parts of Oregon, Idaho, Nevada, and Utah), Desert (Mojave and Sonoran deserts in California, and parts of Nevada, Arizona, New Mexico, and Texas, extending down into mainland Mexico and Baja California Norte), and California (the rest of the state and the coastal region of Baja California Norte).

Landscape Conservation Cooperatives (USFWS 2009) will provide scientific and technical support for landscape-level conservation—such as biological planning, conservation design, prioritizing, and coordinating research, and designing species inventory and monitoring programs. They will provide the connection between science and conservation delivery without duplicating existing partnerships. By functioning as a network of interdependent units, Landscape Conservation Cooperatives are anticipated to be able to accomplish a conservation mission no single agency or organization can accomplish alone.

Landscape Conservation Cooperatives (USFWS 2009) will regularly evaluate the effectiveness of scientific information and conservation actions and support necessary adjustments as new information and data become available. This iterative process of information sharing will help scientists and resource managers deal with uncertainties across the landscape (e.g., climate change) and provide spatially explicit decision-support tools to compare and contrast the implications of management alternatives. The California Essential Habitat Connectivity Map will be a key data source used by each of the four Landscape Conservation Cooperatives that cover California.

7.2.2. California Statewide Conservation

State Wildlife Action Plan. The California Wildlife Action Plan (Bunn et al. 2007) is the State's strategy for wildlife conservation. It answers three primary questions: (1) What are the species and habitats of greatest conservation need? (2) What are the major stressors affecting California's native wildlife and habitats? and (3) What are the actions needed to restore and conserve California's wildlife, thereby reducing the likelihood that more species will become threatened or endangered? The Plan identifies habitat fragmentation as a major stressor on wildlife. Connectivity conservation is identified as a key action both statewide and in four of eight terrestrial ecoregions analyzed in the Plan; however, the Plan did not provide a map or list of priorities for important connectivity areas or linkages. The California Essential Habitat Connectivity Project was designed to fill this need. The Wildlife Action Plan highlights the need to proactively integrate conservation planning with urban and transportation planning, also a goal of the Essential Habitat Connectivity Project, which has fostered partnerships and strategic planning among state agencies responsible for conservation and infrastructure. The Essential Habitat Connectivity map will be used with other biological data sets and decision-support tools in an upcoming revision of the State Wildlife Action Plan.

Wildlife Conservation Board Acquisition Planning. The Wildlife Conservation Board (WCB) acquires land on behalf of the Department of Fish and Game. Starting in 2010, Wildlife Conservation Board acquisition priorities for the Department of Fish and Game will be informed by Areas of Conservation Emphasis Phase II (ACE II), an internal evaluation of biological and recreational value using GIS data and modeling supported by expert opinion. The California Essential Habitat Connectivity Map will be an input data set to ACE II, drawing attention to linkages in acquisition planning.

California Climate Change Adaptation Strategy. The Biodiversity and Habitat Sector of the California Climate Adaptation Strategy calls for creating a large-scale, well-connected, sustainable system of protected areas across the state (California Natural Resources Agency 2009). This strategy follows an assumption that climate change will cause shifts in the ranges and distributions of individual species. Those species that have the capacity to respond will require movement corridors that are not blocked by human development or other disturbances. The Essential Habitat Connectivity Map is a key data set in implementing this strategy, as it identifies natural landscape corridors least resistant to movement by organisms. It provides an important "snapshot in time" of areas on which to focus acquisition in the near future. However, this Project did not explicitly model how climate change may affect any particular species or natural communities, and future work should refine the Essential Habitat Connectivity Map with additional analyses that consider focal resources and their likely responses to climate change, as described in Chapters 4 and 5.

State Conservancies. There are nine State Conservancies established by legislation to help protect regional resources of statewide

Jim Branham, Executive Officer, Sierra Nevada Conservancy: "The Essential Habitat Connectivity Project can assist the Conservancies in their regional planning efforts and may also provide additional data for funding or acquisition assistance. The Sierra Nevada Conservancy collaborates with stakeholders throughout the Sierra in conservation and resource management planning. The Essential Habitat Connectivity Project data can be used to assist in grant review and to inform planning efforts throughout the Sierra with partners."

significance: Baldwin Hills Conservancy, California Tahoe Conservancy, Coachella Valley Mountains Conservancy, San Diego River Conservancy, San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy, San Joaquin River Conservancy, Santa Monica Mountains Conservancy, Sierra Nevada Conservancy, State Coastal Conservancy. These nine Conservancies assist with resource protection in various ways, though most coordinate local efforts, have regional conservation plans, or provide grants and funding assistance. Some hold title or manage land for conservation. The Essential Habitat Connectivity Project can assist the Conservancies in their regional planning and may also provide additional data to prioritize funding or acquisition assistance.

Statewide Land Trusts and Conservation Organizations. There are several national, regional, and state non-governmental or not-for-profit organizations working within the State of California with missions that focus on habitat or land conservation. Some of these non-profit organizations are national or international concerns with locally focused programs, such as The Nature Conservancy, Sierra Club, Audubon, Defenders of Wildlife, PRBO Conservation Science, Center for Biological Diversity, Natural Resources Defense Council, Ducks Unlimited, Quail Unlimited or Mule Deer Foundation, while others are statewide organizations, such as the California Native Plant Society or California Oaks Foundation. Statewide planning efforts such as The Nature Conservancy's Ecoregional Priorities or Audubon California's Important Bird Areas (described in Chapter 3) may use the Essential Habitat Connectivity Map to inform the next iterations of these planning efforts, but ultimately implementation of these plans is done at the regional or local level.

7.2.3. Regional and Local Conservation

Natural Community Conservation Planning and Habitat Conservation Planning. The Natural Community Conservation Planning (NCCP) Program is an unprecedented effort by the State of California and private and public partners that takes a broad-scale, ecosystem approach to planning for sustaining biological diversity while allowing for economic land uses (http://www.dfg.ca.gov/habcon/nccp/). The NCCP Act of 2003 requires every plan to establish linkages between reserves, both within a designated Natural Community Conservation Plan area and to adjacent habitat areas beyond the planning boundary. Because the Natural Community Conservation Planning approach is grounded in the principles of conservation science, which stress the importance of ecological connectivity, nearly every NCCP plan addresses habitat connectivity and wildlife movement corridors in some manner. There are currently 24 Natural Community Conservation Plans around the state (including both completed and in-progress plans), involving over 60 local government jurisdictions, innumerable landowners, federal wildlife authorities, and numerous conservation organizations and other stakeholders. The Essential Habitat Connectivity Map and guidelines can serve as a primary decision-support tool in planning for connectivity within and among individual Natural Community Conservation Plans.

Every year federal dollars are available to states through Section 6 of the Endangered Species Act. Administered by the U.S. Fish and Wildlife Service[57], non-traditional Section 6 Habitat Conservation Planning Assistance grants provide funds for creating Habitat Conservation Plans, through funding of tasks necessary in the plan development phase—for example, baseline surveys and inventories, preparation of plan and environmental review documents, and outreach. The Habitat Conservation Planning Land Acquisition grants provide funds for land acquisitions associated with approved Habitat Conservation Plans. California has been very successful in the national competition for non-traditional Section 6 grant funds. Grant proposals for plans with large geographic areas, multiple species, high match amounts, multiple stakeholders, and high conservation importance score high. Starting with the 2011 grant cycle, each proposal will also be rated on how well the plan proposes to mediate effects of climate change. Since connectivity is the primary climate change adaptation strategy for California (California Natural Resources Agency 2009), those plans that clearly demonstrate attention to habitat connectivity will be considered more competitive.

Regional Land Management Planning. The large land managing agencies in California each coordinate management planning among individual units within their own systems. For example, the U.S. Fish and Wildlife Service has policies for its refuge system; the U.S. Forest Service coordinates revisions of forest plans; and the U.S. National Park Service and U.S. Bureau of Land Management have programs for natural resource management. All agencies have inventory and monitoring programs. In addition, there are community-based natural resource management efforts, such as Coordinated Resource Management Plans. The maps and data created by the Essential Habitat Connectivity Project can be used to help focus management actions in locations where connectivity should be maintained, enhanced, or restored.

> *Don Yasuda, Wildlife Biologist, USDA Forest Service:* "The Forest Service does a lot with our State and Private Forestry program in coordination with private landowners and local governments. We could use a product like this to inform some of our grants to better achieve connectivity objectives through these programs. I also see the Forest Service along with everyone else using this to look at continuing bioregional connectivity planning for climate change adaptation. This information will be a solid base for evaluation of connectivity and climate change adaptation during Forest Plan revision. I think we'll use this data to also inform us for landscape threat evaluations related in the forestlands to wildfire and insect and disease threats to connectivity as well as climate change threats. We could do the same (but with different criteria) in the chaparral and hardwood forest NLBs and corridors. This will help us prioritize and manage functioning landscapes as well as strategize future management for impaired or threatened landscapes."

Regional Conservancies, Land Trusts and Conservation Organizations. Many of these not-for-profit or non-governmental organizations generally have missions to protect, acquire, and restore land for conservation on a local or regional level. Many non-profit organizations work closely with local, state, and federal agencies toward common natural resources conservation goals. Several land trusts and conservancies are focused on specific geographic areas and may target lands that support threatened or endangered species. Some may hold and manage land in perpetuity, while others simply hold land in trust until it can be acquired

[57] Many other funding resources may be available to agencies or organizations for planning purposes. The U.S. Fish and Wildlife Service Pacific Southwest Region maintains a matrix of potential federal, state, local, non-profit and corporate funding that can be accessed at http://www.fws.gov/cno/docs/CPP_Grants.xls.

by a public resources agency. Many organizations have programs focused on environmental education and stewardship, others advocate for conservation of particular lands or species of interest, while others are primarily focused on acquiring land for its habitat and recreational values. There are various ways that non-profit organizations may use the Essential Habitat Connectivity Map depending on the mission of the organization. Land trusts and conservancies may use the products of this Report to target areas for land acquisition or restoration. They may also use this information in educational outreach, in their land management practices, or in grant or funding applications. Some of these organizations may also take a lead role in local or regional connectivity planning and can use these products to inform those efforts. Other conservation organizations may use the Essential Habitat Connectivity Map to advocate for protection or restoration of specific Natural Landscape Blocks and Essential Connectivity Areas.

Landowner Incentive Programs. The California Land Conservation Act of 1965 (commonly referred to as the Williamson Act)[58] enables local governments to enter into contracts with landowners to restrict the use of specific parcels to agricultural or related open space uses in return for much reduced property tax assessments. Local governments then receive an annual subvention of forgone property tax revenues from the state via the Open Space Subvention Act of 1971. As of 2007, approximately 16.5 million acres in state were under the Williamson Act. Due to the state's recent budgetary constraints, subvention payments to local government have been temporarily suspended. It is anticipated that subvention payments will be available again once the economy rebounds. The Williamson Act program will continue to have a significant, positive impact on California agriculture and land-use planning.

The Farm Security and Rural Investment Act of 2002 (Farm Bill) responds to and provides funding for a broad range of emerging natural resource challenges faced by farmers and ranchers, including soil erosion, wetlands, wildlife habitat, and farmland protection. The Farm Bill has several programs, including the Corridor Conservation Program, Farmland Protection Program, Wetlands Reserve Program, and Wildlife Habitat Incentives Program (www.ers.usda.gov/features/farmbill/2002farmact.pdf). Even more conservation incentives are offered in the 2008 Farm Bill. "Safe Journeys: Opportunities for Wildlife Conservation through the Farm Bill" (Environmental Defense Fund, 2009) outlines a number of actions agencies and conservation groups can undertake to maximize the conservation benefits that this updated Farm Bill can deliver.

Strategic Growth Council (SB 732). Senate Bill 732 (Chapter 729, 2008) created the Strategic Growth Council (SGC) which is a cabinet level committee that is charged with coordinating activities of state agencies to improve air and water quality, protect natural resource and agriculture lands, increase availability of affordable housing, improve infrastructure systems, promote public health, and assist state and local entities in the planning of sustainable communities[59]. The allocation of Proposition 84 planning grants and planning incentive funds for encouraging the planning and development of sustainable communities is one program that the Strategic Growth Council administers. The Strategic

[58] http://www.conservation.ca.gov/DLRP/lca/Pages/Index.aspx
[59] http://www.sgc.ca.gov/about_us.html

Growth Council is also required to provide, fund, and distribute data and information to local governments and regional agencies that will assist in developing and planning sustainable communities. The Essential Habitat Connectivity Project products can help the Strategic Growth Council meet their intent and objectives, to expedite the development of regional transportation and land use modeling by supporting the data gathering and model development necessary to comply with SB 732 and provide policy level guidance on integrating the protection of essential habitat connectivity areas in strategic growth analyses.

Conservation in General Plan Updates for Cities and Counties. All of California's 480 cities and 58 counties are required to prepare General Plans for their long range growth and development. The Governor's Office of Planning and Research is required to adopt and periodically update General Plan Guidelines for local jurisdictions to use in preparing their general plans. The 2003 guidelines are currently being updated, providing an opportunity to recommend how information and strategies produced by the California Essential Habitat Connectivity Project can be incorporated into local land use planning.

7.3. Coordinated Infrastructure and Mitigation Planning: Policy and Funding Opportunities for Connectivity

7.3.1. Statewide Infrastructure Planning

California Transportation Plan 2035. The California Transportation Plan 2035 is a statewide, long-range (20-year) plan that spells out the goals, policies, and strategies for meeting California's future transportation needs at the local, regional, and state level. Policies designed to enhance and conserve environmental resources in the 2035 Plan include: (1) integrate land use, transportation, and environmental planning; (2) promote environmental stewardship and sustainability; (3) integrate environmental considerations into all aspects of transportation decision-making; and (4) identify and implement climate change mitigation and adaptation strategies. This plan provides strategic direction to California's 44 regional transportation-planning agencies that are responsible for planning, prioritizing, and funding regional transportation plans. The 2035 Plan is currently being updated to meet new trends and challenges, such as climate change, to better integrate transportation planning with environmental and natural resource planning (e.g., SAFETEA-LU), providing a timely opportunity for integrating the results of the Essential Habitat Connectivity Map.

> *Larry Vinzant, Federal Highways Administration*, "The Essential Habitat Connectivity Project could provide valuable information that could be incorporated into the transportation planning process. Identification of essential habitat early in the planning process would allow the stakeholders to consider alternatives that would avoid impacts to the habitat and/or incorporate important mitigation features such as wildlife crossings. By having the data available on a region or statewide basis, transportation planning agencies could identify how all of the proposed projects in the Regional Transportation Plan impact essential habitat, rather than looking at it piecemeal on a project-by-project basis. The project's products also could provide valuable insight into the long-term ramifications of climate change and help address new initiatives such as livable and sustainable communities, of which the natural environment is an important component."

The Essential Habitat Connectivity Map clearly furthers the goal of maintaining a connected California. It can also help to make transportation planning projects more cost efficient and help reduce dangerous interactions between vehicles and wildlife. Transportation planners will now be able to take into account Essential Connectivity Areas early in their planning processes, which will allow them to take connectivity conservation actions early, when such decisions are both less costly and more effective. For example, the Essential Habitat Connectivity Map could be used to adjust proposed road alignments or to design wildlife crossing structures during planning and design of a transportation project, rather than addressing project impacts to habitat connectivity later, as expensive remedial actions. In planning for existing highway enhancements, agencies such as the California Department of Transportation may prioritize enhancement or remediation for highways crossing Essential Connectivity Areas or Natural Landscape Blocks where animal-vehicle collisions could pose a safety threat.

> *Gregg Erickson, California Department of Transportation*, "As we look at growth, development and climate change, evaluating areas in the state essential for habitat connectivity and wildlife movement is critical to help us evaluate how we can adapt. The California Essential Habitat Connectivity Project provides a new bridge between local/regional wildlife fragmentation studies and the long awaited statewide inter-regional view of habitat connectivity contained within the report. This will inform policies such as the California Transportation Plan and Wildlife Action Plan and establish a framework and data set for finer scale consideration during local planning with a new found ability to integrate local and statewide perspectives in a transparent manner. The collaborative effort that produced this report will be critical to help us adapt as we move forward focusing on the most effective and efficient solutions. We look forward to expanding our partnerships as we plan together for infrastructure as well as natural resources."

The Essential Habitat Connectivity Map provides information that can assist planners with integrating transportation planning with natural resource planning and meet challenges posed by climate change. Many spatial data layers generated by this project will be available through BIOS (http://bios.dfg.ca.gov) and Data Basin (http://databasin.org) (see Chapter 8). Yet another tool is the California Transportation Investment System, which maps short- and long-range projects planned by State and regional transportation agencies. All three of these systems provide transportation and land-use planners with tools to evaluate planned and programmed project locations relative to Natural Landscape Blocks and Essential Connectivity Areas, and thus to identify opportunities for maintaining, improving, or restoring functional habitat connectivity across existing or planned transportation barriers. The California Transportation Investment System displays the existing transportation system along with programmed transportation improvement projects that are currently underway and where projects will be planned over the next 20 years. Information on programmed and planned projects includes highway, local, rail, airport, bicycle, pedestrian, transit, and Proposition 1B projects at both the state and regional levels.

California Water Plan. The California Water Plan (California Department of Water Resources 2009) is the state's water strategic plan. The plan, which is updated every five years, presents basic data and information on California's water resources, including water supply evaluations and assessments of agricultural, urban, and environmental water uses, to quantify the gap between water supplies and uses. A component of the plan focuses on how

to coordinate water planning with land-use plan plans and programs of other state agencies. Volume 1, Chapter 3, of the 2009 update outlines companion state plans, including those related to conservation, such as the California Wildlife Action Plan (Bunn et al., 2007) while Volume 1, Chapter 6, calls for improved data and analysis to facilitate such integrated planning. The Essential Habitat Connectivity Project helps to fill an identified gap in environmental data.

7.3.2. Regional and Local Infrastructure and Mitigation Planning

California Regional Blueprint Planning Program. The California Regional Blueprint Planning Program, administered by the California Department of Transportation, provides essential support for integrated regional transportation and land-use planning to achieve sustainable regional growth patterns that includes protecting natural resources. This program has provided a vital source of funding for comprehensive regional planning efforts throughout the State of California. There are 44 Metropolitan Planning Organizations and Regional Transportation Planning Agencies throughout the state. Since the inception of the Blueprint Program, 17 Metropolitan Planning Organizations and 14 Regional Transportation Planning Agencies have participated in blueprints or blueprint related efforts. One of the primary elements of the program is regional scenario planning to engage the public and stakeholders in identifying a preferred growth scenario. Blueprint Planning processes can use the Essential Habitat Connectivity Map to provide connectivity related constraints to growth during scenario planning. It can also be used to identify areas where regional connectivity analysis (Chapter 4) or Linkage Designs (Chapter 5) should be developed and incorporated into scenario planning to provide more detail. Similar planning processes taking place in response to SAFETEA-LU 6001 requirements in the preparation of Regional Transportation Plans or SB375 Sustainable Community Strategies can also use the map. While the data generated for the Essential Habitat Connectivity Map may be appropriate to incorporate into the simulation computer modeling in some areas, finer-scale regional connectivity analyses will likely be necessary for most regions of California. Agencies engaged in specific transportation projects that occur in Natural Landscape Blocks or Essential Connectivity Areas should consider developing a Linkage Design (Chapter 5) and address improving connectivity across transportation barriers (Chapter 6).

Regional Advance Mitigation Efforts. Some agencies responsible for multiple infrastructure projects are proactively attempting to mitigate their habitat level impacts by integrating their obligations into regional conservation objectives. The Regional Advance Mitigation Planning (RAMP) effort is evaluating ways to integrate regional conservation designs and mitigation assessment for Department of Water Resources and Caltrans projects in a particular region collectively, by evaluating the expected spatial extent of habitat impacts and associated mitigation requirements. Areas are identified by considering several natural resource data sets in conjunction with anticipated impacts associated with specific resources and habitat types. The California Essential Habitat Connectivity map and data can be considered in this analysis to help connect the network/mitigation plan design and to reflect connectivity in a regional advance mitigation plan. Should funding mechanisms become available to implement a Regional Advance Mitigation Planning program, investments in more holistic mitigation planning and implementation are possible. A good on-the-ground example of advance mitigation efforts at a regional scale is The Elkhorn Slough Early

Mitigation Partnership (http://elkhornslough.ucdavis.edu/). It provides early mitigation for a series of future transportation improvement projects within the Elkhorn Slough Watershed. Conservation and mitigation banks, described below, are heralded as an example for the RAMP effort and could provide a tool for advanced mitigation.

Conservation and Mitigation Banks. A conservation or mitigation bank is privately or publicly owned land managed for its natural resource values and established in advance of compensatory mitigation needs. In exchange for permanently protecting the land, a bank sponsor is authorized by regulatory agencies to sell credits as compensation for specific impacts to habitats and species within a defined service area. These credits may be sold to developers or other infrastructure agencies needing to satisfy permit or other legal requirements for projects that significantly impact the environment.

Both types of banks can have a habitat and listed species component. However, mitigation banks specifically have a Clean Water Act Section 404 component overseen by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA). In California, the Department of Fish & Game has oversight authority for both types of banks and partners with federal agencies, such as U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish & Wildlife Service and the National Marine Fisheries Service, who share similar regulatory authorities and compensatory mitigation requirements.

Banks help consolidate small, fragmented mitigation projects into larger contiguous sites with higher habitat values. Depending on their location, they can significantly contribute to habitat connectivity. The California Essential Habitat Connectivity Map and associated data can contribute to the strategic siting of new conservation and mitigation banks, thereby increasing habitat connectivity. The Department of Fish & Game will be better positioned to recommend to bank sponsors priority areas for banks[60].

Infrastructure Budget Cycle: Funding for Connectivity Planning. Government agencies that develop such infrastructure as roads, waterworks, and energy delivery often impact natural ecosystems, but they also have unique opportunities to contribute to the conservation of regional natural resources through compensatory mitigation. Infrastructure development requires a planning, funding, and implementation cycle that can frequently take a decade or longer, but biological mitigation is often planned and implemented late in this process, on a piece-meal project-by-project basis. If infrastructure agencies (or other regional planning entities) consider products of the California Essential Habitat Connectivity Project in long-range planning as suggested above, they can program the needed funds to implement connectivity within each region. Exploring funding estimates for necessary data development, enhancement, avoidance, minimization, or mitigation opportunities will allow agencies to budget for these improvements either in advance of specific projects or associated with specific projects. Impact fees or mitigation fees may provide funding for implementation as well as avoidance measures. Local taxes or assessments, such as TransNet in San Diego County, can also be considered for this purpose.

[60] http://www.dfg.ca.gov/habcon/conplan/mitbank/mitbank_policies/cmb_notaccept.html

7.4. Legislative Framework for Assuring Connectivity

Below we present state and federal legislation that is key to supporting or ensuring the conservation of connectivity in California.

Assembly Bill 2785. Introduced by Assembly Member Ira Ruskin and passed in 2008, this bill directs the California Department of Fish and Game to map essential wildlife corridors and habitat linkages. Amendments to Section 1932 of the California Fish and Game Code are as follows: "*Develop and maintain a spatial data system that identifies those areas in the state that are most essential for maintaining habitat connectivity, including wildlife corridors and habitat linkages. This data should include information essential for evaluating the needs of wildlife species, as defined in Section 711.2 that require habitat connectivity for their long-term conservation, including distribution and movement patterns.*" Not only has the Essential Habitat Connectivity Project gone a long way towards meeting this mandate, the mandate itself sets up funding possibilities from the state budget for future analyses. The Department's effort to provide detailed mapping of vegetation data has also been expanded as a result of this legislation, further assuring that the data necessary for regional connectivity analyses and detailed Linkage Designs are available when needed.

The Safe Accountable Flexible Efficient Transportation Equity Act of 2005 (SAFETEA-LU). The Safe Accountable Flexible Efficient Transportation Equity Act of 2005 (SAFETEA-LU) is currently up for reauthorization[61]. Section 6001 of SAFETEA-LU requires state and regional transportation planning agencies to complete regular plans and transportation improvement programs that identify proposed transportation and transit enhancement activities. SAFETEA-LU further directs agencies to incorporate natural resource considerations directly into transportation planning analysis and documents. Information about types of potential environmental mitigation activities and comparison with other relevant plans, including state conservation plans or maps and inventories of natural or historic resources, is also required. The Essential Habitat Connectivity Map can inform state, regional, and local transportation plans and integrated planning efforts about natural areas that are crucial to the continued functioning of the state's ecosystems.

NCCP Act of 2003. The NCCP Act of 2003 requires every plan to establish linkages between reserves, both within a designated Natural Community Conservation Planning area and to adjacent habitat areas beyond the planning boundary. The Essential Habitat Connectivity Map and guidelines should serve as a primary decision-support tool in planning for connectivity, especially regional connectivity across the boundaries of individual Natural Community Conservation Plans.

California Environmental Quality Act (CEQA). The results of the Essential Habitat Connectivity Project can be used in evaluating California Environmental Quality Act projects. The California Environmental Quality Act checklist specifically asks whether a proposed project would "interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites". If the boundary of a proposed

[61] http://www.fhwa.dot.gov/reauthorization/

project is in the vicinity of an Essential Connectivity Area, it should be called out as a potentially significant biological effect in California Environmental Quality Act comment letters by the California Department of Fish and Game, the trustee agency for fish and wildlife resources of the state. Further analysis or the development of a Linkage Design (Chapter 5) may be necessary to ensure a project can avoid, minimize, or mitigate impacts to connectivity.

California Endangered Species Act (CESA). The California Endangered Species Act establishes a petitioning process whereby individuals, organizations, or the California Department of Fish and Game can submit petitions to the Fish and Game Commission requesting that a species, subspecies or variety (taxa) of plant or animal be state-listed as Threatened, Endangered, and (for plants only) Rare. As with the federal Endangered Species Act (below), it provides law and regulations for the conservation of such listed taxa. Sections 2050 et seq. of the Fish and Game Code declare intent and policy that all state agencies seek conservation for listed taxa and define conservation to include -- among many other measures -- habitat acquisition, restoration and maintenance. The California Essential Habitat Connectivity Project will help agencies locate places to acquire or restore habitat where it will be most effective, particularly for species that require large connected areas across the landscape.

National Environmental Policy Act (NEPA). The National Environmental Policy Act requires federal agencies to integrate environmental considerations and impact analysis into decision making processes and alternatives development for projects or program level plans. The products of the California Essential Habitat Connectivity Project can help federal agencies analyze the significance of effects related to a proposed action. A regional or local level connectivity analysis may be needed in order to obtain the appropriate level of detail for determining significance or informing alternatives analysis.

Endangered Species Act (ESA). The Federal Endangered Species Act provides law and regulations for the consideration of the conservation and recovery of federally-listed Threatened and Endangered species. (For purposes of the ESA, species are defined to include subspecies, varieties and, for invertebrates, distinct population segments.) When evaluating the effects of a federal, state or local action on species covered by the Act, an assessment of the needs of a particular species for feeding, breeding, and shelter are considered. Feeding, breeding and shelter often includes the connectivity of habitat so that a species may access areas for different life cycle activities. The regional and local level analysis will help identify the areas essential for species covered under the Act. Simply considering a particular species and its range and population can provide insight for an effects analysis.

Clean Water Act (CWA). The objective of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's waters by preventing point and nonpoint pollution sources, providing assistance to publicly owned treatment works for the improvement of wastewater treatment, and maintaining the integrity of wetlands. The Essential Habitat Connectivity Map depicts biological integrity of habitats that include the

nation's waters and wetlands. Note that the analysis did not specifically focus on aquatic or invertebrate movement; however, wetlands and associated habitats are represented. A regional or local level analysis might appropriately have more of an aquatic than a terrestrial focus, depending on the region.

Chapter 8. Framework for Data Distribution and Evaluation

Through the methods and decision processes described in the previous chapters, numerous spatial data layers (GIS layers) were generated by this project. To maximize the utility of the products, many of the final data layers will be made available to the public in electronic form. A selected set of final results data layers will be published from two separate websites—initially from BIOS, managed by California Department of Fish and Game (http://bios.dfg.ca.gov), and soon afterward from Data Basin, managed by the Conservation Biology Institute (http://databasin.org). Both are interactive web-based systems that will allow users to gain access to the data layers created from this project, but they offer different capabilities and user experiences (Figure 8.1).

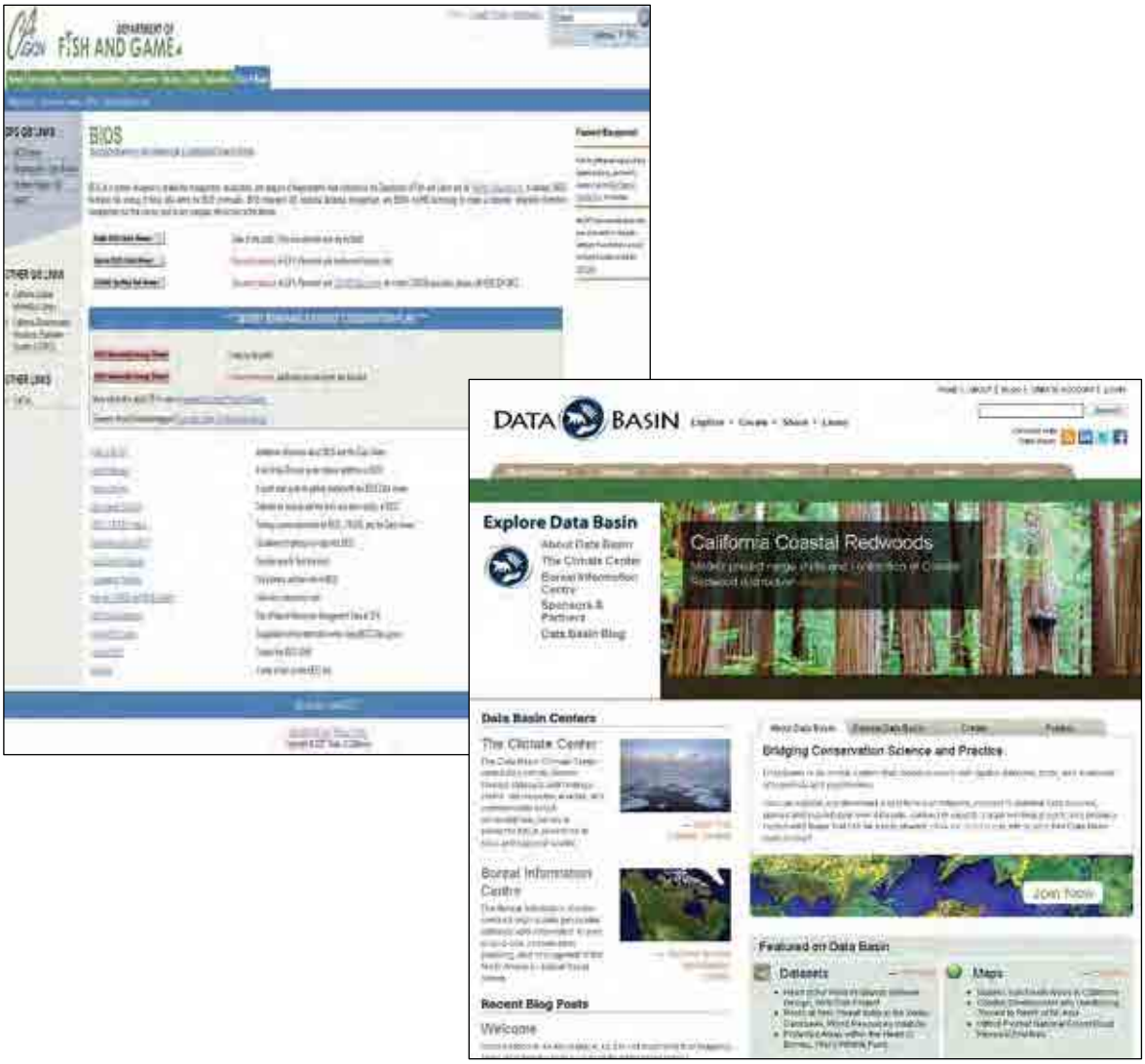


Figure 8.1. Snapshots of BIOS (http://bios.dfg.ca.gov) and Data Basin (http://databasin.org) website homepages.

8.1. GIS Layers and Metadata

Of the many hundreds of data layers generated during the project, the key input data layers created for the analysis (e.g., Natural Landscape Blocks and resistance surface) and final results data layers (e.g., Essential Connectivity Areas) will be provided via BIOS and Data Basin (Table 8.1). For each data layer, complete metadata will be included. From the BIOS and Data Basin sites, public data layers will be downloadable from ESRI's ArcGIS Online site as ESRI layer packages, which include the file geometry, attributes, metadata, and styling (http://www.esri.com).

Table 8.1. List of data layers provided electronically in BIOS and Data Basin.

Data Layer Name	Description File	File Format
NLB_gen	General Natural Landscape Blocks	Polygon Feature Class
NLB_dissect	Natural Landscape Blocks dissected by major and secondary roads (used as termini in least-cost corridor modeling and to generate comparison statistics)	Polygon Feature Class
Sticks	Diagrammatic linear linkage between centroids of Natural Landscape Blocks	Line Feature Class
ECAs	Unsplit version of the Essential Connectivity Areas (n=168)	Polygon Feature Class
ECAs_split	Split version of the Essential Connectivity Areas (n=192)	Polygon Feature Class
Least_Cost_Corridors	Mosaic of least-cost corridor results for all Essential Connectivity Areas. The minimum cell value was used for overlapping cells.	Raster Dataset
Cost_Surface	Statewide resistance surface generated for least-cost path models	Raster Dataset
NatAreas_small	Natural areas smaller than 2,000 acres that otherwise meet NLB criteria	Feature Class

8.2. Ability to Map and Print Locally

Both BIOS and Data Basin will allow users to visualize the data layers provided from the project in conjunction with other data layers already hosted by each system (Figure 8.2). The public map interface for BIOS uses ArcIMS technology and allows the user to conveniently turn a pre-selected set of data layers on or off (using pre-rendered styling) against a shaded relief map of California. The individual datasets from this project will be uploaded into BIOS and provided as options for users to see. Also, users have access to pertinent metadata for each data layer hosted on the site, and they can print the map results easily from a standard map template.

Data Basin is deployed on the Amazon cloud and operates using ArcServer technology with additional functional support provided from ArcGIS Online. The map interface includes several ESRI basemaps that can be easily selected, and against which users can visualize any collection of datasets found in the Data Basin data library or other available map services outside of Data

Basin (Figure 8.2). Once in the map viewer, users are given the tools to easily style (i.e., change colors and symbols on) their own map and then save them to the system within their own workspaces. A user's workspace can either be kept private or shared with others.

The individual datasets from the connectivity project will be uploaded into Data Basin and placed into a project folder called the California Essential Habitat Connectivity Project. This published project folder will also contain many of the maps provided in the report in an editable form. Users can essentially open each map and download or print "as is" or customize it in some way. They can change styling of the existing layers and/or add other data layers, searchable from the system or uploaded by them. Users will be permitted to download all datasets as ESRI layer packages (Zipped files containing file geometry, attribute tables, metadata, and styling information) for direct use on their own desktops using ArcGIS.

Both BIOS and Data Basin provide links to important documents. In both systems, links to the full report (including appendices) will be made available.

Figure 8.2. Snapshots of BIOS and Data Basin website map interfaces. Data Basin provides two different views (partial and full screen).

8.3. Ability to Add New Data Layers Over Time

Both BIOS and Data Basin allow the addition of data layers over time. BIOS managers and agency partners select relevant biological datasets to host and provide users access in accordance with data custodian wishes. For many data layers, BIOS provides free public access. For data

identified by the custodians as sensitive data, access is controlled using a password system. As new data layers become available or existing data layers are updated, BIOS will expose them.

Data Basin was developed to be a spatial data sharing site and allows users to upload their own data layers into the system. Although data sharing remains Data Basin's primary focus, some datasets are sensitive by nature. Therefore, users are given complete control over access – they can elect to keep their data layers completely private, useable only by a select group of other Data Basin users, or made totally public (at which time the data layer is searchable by the system). In the context of the connectivity project, users will always have access to the final results data layers as well as any new layers that either they upload themselves or are provided by others.

Regardless of the system used, data sharing and access is an important common need. Without sharing, making better planning and management decisions becomes impossible. Over the years, technology has evolved rapidly – perhaps faster than our society can adjust. The major challenges to data and information access are no longer technical; they are social. Rigid control of data and information has had direct benefits to individuals and institutions. This long-held practice has resulted in financial rewards, job security, and power over decision making. As we rapidly move into the Web 2.0 world, sharing is becoming more commonplace and society is finding incentives to encourage this important behavior. Effective connectivity planning requires the most current and accurate spatial data available, and these data are generated by many different parties. Data sharing and access will continue to be critical as we move into the future.

As part of this project, the team is publishing the data and results using the Internet to allow maximum accessibility and tools to help all users understand habitat connectivity better. These user-friendly tools also allow users to make their own customized maps, add new datasets, and find people of similar interests or specific expertise. It is the hope of the project team that this body of work will not be the end, but a beginning. Connecting California's wild spaces into a functional natural network will require the involvement of many, and learning from each other is critical to success. By publishing the data and information from this project as described in this chapter, we hope users will continue to add to this body of knowledge so that all of us can learn and move toward this common vision.

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Appendices

A. Work Plan

B. Detailed Characteristics of Essential Connectivity Areas

C. Detailed Characteristics of Natural Landscape Blocks

D. List of Acronyms

E. New Approaches to Analysis of Connectivity

California Essential Habitat Connectivity Project
Work Plan
April 2009

Introduction: The California Department of Transportation (Caltrans), in partnership with the California Department of Fish and Game (CDFG), has commissioned a team of technical consultants (Consulting Team) to assist them in producing a statewide assessment of essential habitat connectivity. Caltrans intends to use this assessment to comply with Section 6001 of SAFETEA-LU and thus avoid, minimize, or mitigate impacts to habitat connectivity during the planning process. CDFG will also use the statewide assessment in updating the State Wildlife Action Plan and in complying with AB2785 and SB85. CDFG and USFWS intend the assessment to assist them in developing NCCPs and HCPs. The assessment may also assist metropolitan planning organizations in complying with SB375 and related laws.

On October 7, 2008, a Multidisciplinary Team (MDT) of stakeholders from various federal, state, and local agencies was convened to discuss desirable characteristics of the following three primary products of the California Essential Habitat Connectivity Project.

1. A statewide map depicting areas essential for habitat connectivity.
2. A matrix summarizing biological values of the linkages to inform conservation decisions.
3. A strategic plan that outlines an approach for finer-scale analyses and local or regional connectivity plans, which are to be performed outside the scope of this statewide assessment.

Also at the October 7, 2008 workshop, some members of the MDT volunteered to assist the Consulting Team in making key technical decisions regarding these three products. These volunteers are called the Technical Advisory Group (TAG). The TAG met at a workshop on January 29, 2009 to discuss the

Abbreviations

AB2785: Requires CDFG to map essential wildlife corridors and habitat linkages.
ACE: Areas of Conservation Emphasis being defined by CDFG.
Caltrans: California Department of Transportation.
CDFG: California Department of Fish & Game.
CNDDB: California Natural Diversity Database.
Consulting Team: Consulting Team contracted for this project, including The Dangermond Group, Conservation Biology Institute, SC Wildlands, and Paul Beier, working collaboratively with Caltrans and CDFG representatives.
HCP: Habitat Conservation Plan developed under Section 10 of the US Endangered Species Act.
MDT: Multidisciplinary Team of representatives from federal, state, and local agencies involved in conservation, land-use, or transportation planning and implementation.
NCCP: Natural Communities Conservation Plan.
SAFETEA-LU: Safe Accountable Flexible Efficient Transportation Equity Act of 2005.
SB375: Requires regional transportation plans to include strategies to meet goals for reducing greenhouse gas emissions.
SB85: Requires CDFG to develop vegetation mapping standards.
SWAP: State Wildlife Action Plan.
TNC: The Nature Conservancy.
TAG: Technical Advisory Group. A group of about 30 volunteers from local, state, and federal government who are assisting the Consulting Team make key technical decisions.

approach for producing the first two products: (1) the Statewide Essential Habitat Connectivity Map and (2) the Matrix of Biological Value of the Linkages (formerly "prioritization"). The Strategic Plan (product 3) will be developed based on ongoing input from the TAG and MDT.

Project Mission Statement: The purpose of the California Essential Habitat Connectivity Project is to develop a habitat connectivity map and a plan that will help infrastructure, land use, and conservation planners maintain and restore a connected California, while simultaneously making infrastructure planning projects more cost efficient.

Purpose of Work Plan: The purpose of this Work Plan is to guide the consultant team, provide an outline that identifies specific steps that require TAG input, and serve as the primary document for outside peer review. With distribution of this Final Work Plan we are at Action Step 2.3 (having revised the Draft Work Plan based on initial TAG input and outside peer review; see below).

Review and Input Process: We will hold web based meetings with the TAG at appropriate milestones in the process to obtain input and review of interim products. We will use Data Basin as a method of sharing, receiving input, and refining maps, models, and other work products throughout the project. Data Basin is an innovative web tool (http://databasin.org/about_data_basin) that connects users with conservation datasets, tools, and expertise. Individuals and organizations can explore and download a vast library of conservation datasets, upload their own data, comment on or add to other's data, and produce customized maps and charts that can be easily shared. In addition we will hold one additional workshop with the TAG to review products, and one final workshop with the MDT (outlined below).

Strategic Action #1: Reach Consensus on Work Plan Approach

(Completed March 2009)

Action Step 1.1: Produce a Draft Work Plan prior to the January 29, 2009 meeting that includes options for the TAG to consider.

Action Step 1.2: Develop and provide background materials to the TAG prior to meeting.

Action Step 1.3: Hold the January 29, 2009 meeting with the TAG to evaluate options and criteria for constructing and prioritizing statewide habitat connectivity map and reach consensus on the Work Plan approach.

Action Step 1.4: Revise the Work Plan based on information received from the TAG at the January 29, 2009 meeting. Include details on specific action steps that need to be completed, determine the schedule, and identify the individuals responsible for each step.

Action Step 1.5: Circulate revised Work Plan to the TAG for review and input.

Strategic Action #2: Outside Peer Review of Planned Approach
(Completed April 2009)

Action Step 2.1: Peer review. We asked academic experts in conservation biology, conservation planning, and linkage design not associated with this project to review the Work Plan and background materials from the January 29, 2009 TAG meeting (e.g., approach document and associated appendix). We will also request that they review subsequent products as they are completed via Data Basin. Comments on the Draft Work Plan received from the following experts were used to complete this Final Work Plan: Dr. Reed Noss (University of Central Florida), Dr. Kevin Crooks (Colorado State University), Dr. Dave Theobald (Colorado State University), Dr. John Wiens (PRBO Conservation Science), and Dr. Kate Wanner (Trust for Public Land). No stipends were available for this task.

Action Step 2.2: Circulate work plan. Circulate work plan and comments from the peer reviewers to the TAG for a second review and input cycle.

Action Step 2.3: Finalize work plan. Finalize work plan based on comments received in Steps 2.1 and 2.2.

Strategic Action #3: Construct Statewide Wildlife Habitat Connectivity Map (September 2009 targeted completion date)

The goal for this strategic action is to identify, at a gross, statewide scale, areas where maintaining or restoring functional ecological connectivity is essential to conserving the state's biological diversity. The intent is to create a baseline map of essential connectivity areas, based largely on GIS data layers that reflect ecological integrity or "naturalness" of land features, and therefore likely to reflect the needs of diverse species and ecological processes. Thus, this statewide map will provide a relatively "top-down, broad-brush" depiction of essential connectivity areas, with the intent that finer resolution mapping and analysis will later be performed (outside the current scope of work) using finer resolution and "bottom-up" (e.g., species-based) modeling and analyses.

The Strategic Plan (Strategic Action #6) will provide detailed recommendations for how to perform these additional analyses and delineate essential connectivity areas at ecoregional and local scales. The approach for developing the statewide map has been designed to be conservative — erring on the side of being inclusive rather than exclusive of essential connectivity areas. It is also to be as transparent, scientifically defensible, and repeatable as possible.

This statewide connectivity map will not be developed using explicit climate-change models or other future scenario analyses. The Strategic Plan will recommend additional analyses that could be used to address future changes, including adaptation to climate change, under future scenarios.

This process will not explicitly address freshwater or marine connectivity issues. However, natural riparian corridors are considered in identifying essential connectivity

areas because they are important to maintaining diverse geological and ecological processes and facilitate movements of diverse species, including terrestrial as well as aquatic species.

Action Step 3.1: Assemble and prepare data layers. The Consulting Team will work with MDT to identify and obtain all essential and available data layers, including GIS and ancillary data that can inform the analyses.

Action Step 3.2: Define analysis area. The analysis area is defined as the entire state of California plus a buffer into adjacent Oregon, Nevada, Arizona, and Baja California to ensure that cross-border connections are also addressed.

To define the buffer into adjacent states and Baja California we will use a biologically driven but flexible set of rules. This flexible rule set may define the analysis extent by using one or more of the following techniques: (1) the edge of the nearest areas of high ecological integrity outside of the state, (2) edge of nearest protected areas (e.g., based on GAP 1 & 2 ratings)[1], and (3) the edge of known, important habitat areas for key species (e.g., desert tortoise recovery areas). We will focus our attention within the state and depict cross-border linkages with placeholder arrows, indicating future collaboration with neighbors.

Action Step 3.3: Conduct analysis to define natural landscape blocks. We will define *natural landscape blocks* as any large (size to be determined based on pilot testing and TAG input) existing natural open space having relatively high ecological integrity. For this exercise, ecological integrity will be defined by a select set of surrogate data themes that provide our best estimate of relative levels of naturalness. Additional biological modifiers may be added to further discriminate the California landscape. The model for mapping natural landscape blocks will be based on the following criteria:

- Road Density:
  ESRI StreetMapNA Major roads data (9.3, 2008) for US, 1:100,000, vector

- Percent Impervious Surface:
  National Land Cover Database 30m raster, 2001, US Geological Survey

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[1] GAP Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management.

GAP Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.

- Percent Agriculture (not including rangelands):
  LANDFIRE.EXISTING_VEGETATION_TYPE, USDA Forest Service, 90m grid, 2006; and FRAP

- Percent Urban (using one or more of the following):
  - FRAP, Multi-Source Land Cover Data (CWHR), raster, 2002, 100m
  - LANDFIRE.EXISTING_VEGETATION_TYPE, USDA Forest Service, 90m grid, 2006
  - FRAP, Development Footprint, 2002, 30m, 1:100,000 (derived from Census housing density, and USGS land cover data).
  - NLCD, Land Cover, 21 broad land cover classes, raster, 2001, 30m

- Conservation Status (appropriately weighted to reflect correlation with biodiversity protection, combining the following databases):
  - Conservation Biology Institute Protected Areas Database 2008
  - SC Wildlands Protected Lands for the south (using data from The Nature Conservancy, Santa Monica Mountains Conservancy, National Park Service, and California Protected Areas Database as of November 2008).
  - GAP status codes weighted according to level of protection.

<u>Potential Biological Modifiers</u>

- Vernal Pools and Wetlands:
  - Central Valley Vernal Pool Complexes, DFG, 1998
  - California Central Valley Wetlands and Riparian GIS, DFG, 1997
  - Placer County Vernal Pool Resource Inventory, DFG, 2000
  - South Coast Ranges Vernal Pools, DFG, 2003
  - California Wetlands, USFWS, 2006
  - Wetland Reserve Program Lands, if available

- Rarity-Weighted Richness Index (includes rare plants substrates):
  CDFG, 2009, grid cell size to be determined

- Essential Habitat identified by USFWS for Federally listed species.
  Essential Habitat includes geographic areas essential to a species' conservation, including those areas that may be excluded from designated Critical Habitat for economic or other reasons, such as coverage in long-term conservation agreements.

Data resolution will be 100m. We will apply a relatively fine moving-window averaging algorithm to produce a map showing a gradient of ecological integrity. We will evaluate different window sizes, weights, and criteria to avoid losing smaller natural landscape blocks in developed areas. Pilot analyses suggest that a moving window of about 5 km is best. The approach will include model logic that employs neighborhood averaging, weighting, and "or" logic functions to avoid inappropriately competing criteria against one another (for example, an area could be of high ecological integrity in part due to presence of vernal pools *or* rare plant substrates *or* Essential Habitat, etc.).

From the results, we will select thresholds for the level of integrity and the size of contiguous areas that will constitute our natural landscape blocks. Areas outside these blocks will be treated as matrix lands through which connectivity needs will be assessed. We may use different thresholds in different ecoregions in order to delineate the best remaining blocks. The threshold may be specified as a rule, (e.g., greater than a certain percentile of integrity within each ecoregion, or within a large subset of an ecoregion) but the rationale will be clearly defined. The TAG was comfortable with a minimum size of about 6,000 acres, but perhaps smaller in more developed ecoregions (e.g., <2000 acres in Central Valley), or larger in wilder ecoregions (e.g., Sierra Nevada). The TAG will have an opportunity to review the initial determinations for size thresholds in Action Step 3.5.

Action Step 3.4: Determine which pairs of natural landscape blocks to connect. After natural landscape blocks are defined, we will use expert opinion to determine which blocks should be connected using such factors as landscape context (e.g., are the blocks adjacent?), ecological context (e.g., do the blocks share species that require movement?), existence of barriers (are there absolute barriers between blocks that cannot be mitigated?), and ecological processes (would connecting these blocks accommodate migrations or ecological shifts due to climate change or disturbance factors?). We will attempt to develop a repeatable set of rules for this step, and will describe the factors we considered and our rationale for each linkage. The Consulting Team will take the first pass at identifying the proposed linkage network for the state and post the draft map and ancillary datasets (e.g., Penrod et al. 2001) on Data Basin for the TAG to review and provide input.

Action Step 3.5: Provide draft results of action step 3.3 and 3.4 to the TAG for review and comment. The maps and ancillary datasets used by the team in previous steps will be provided via Data Basin. Reviewers can also evaluate results using their own data layers. We will provide a summary document and supporting data as necessary. Members of the TAG who comment or make suggested edits to the map must also explain their rationale. We will have either a conference call or webinar with the TAG to familiarize them with Data Basin and walk them through the approach for this step. The TAG will have two weeks after the webinar to submit comments.

Action Step 3.6: Incorporate revisions from TAG.

Action Step 3.7: Conduct analyses to delineate essential connectivity areas. We will use *least-cost corridor modeling* to define *essential connectivity areas* for each pair of natural landscape blocks that are determined to require connectivity. We will use the centroid of each natural landscape block as terminuses for each analysis.

To develop the resistance surface or cost raster for least-cost modeling we will use data inputs with a resolution of 30m or 100m. Criteria that may contribute to the cost surface include:

- road density or distance to road

- railroads
- percent natural landcover (100m), or natural vs. not natural landcover (30m) Different categories of urban and agriculture will be defined relative to their likely effects on overall habitat permeability, based, for example, on number of dwelling units/acre or type of agriculture (row crops, rice, vineyards, or orchards). Rangelands will generally be considered natural grasslands rather than agriculture.
- percent impervious surface
- percent wetland or riparian

We will then add natural streams that provide potential aquatic or riparian connections between the natural landscape blocks if a linkage polygon does not encompass these streams already. Streams will be buffered on each side out to 250 m or to any substantial barriers to movement, such as urban edge.

For five sample essential connectivity areas, we will compare our coarse-level modeling results with finer scale connectivity model results based on focal species. Comparisons will be focused in areas in which fine-scale linkage designs based on multiple focal species, some of which are listed and sensitive, have been completed (e.g., for the South Coast Missing Linkages project; Beier et al. 2006). To the degree possible, these five areas will be representative of different ecoregions throughout the state.

We will define the cost threshold to apply throughout the state (or ecoregion) using a threshold that encompasses all focal species' least-cost corridors. For example, if the most permeable (lowest cost) 5% threshold based on ecological integrity encompasses all focal species' least-cost corridors in all five sample areas, we would use 5% as the threshold for least-cost modeling in all essential connectivity areas. This analysis should help reassure users who are skeptical of using ecological integrity as the resistance layer by selecting a cost threshold that is likely to accommodate the needs of diverse focal species.

If the comparison shows that the ecological integrity raster based approach is severely lacking, we will explore adding a limited number of additional datasets to improve the performance.

Action Step 3.8: Evaluate utility of essential connectivity areas. We will select an illustrative subset of essential connectivity areas (at least one per ecoregion), and describe and evaluate the utility of each through (1) review by species experts, and (2) comparison of our polygons with maps produced by other linkage planners (Davis and Cohen 2008, Penrod et al., 2008, 2006, 2005, 2004, 2003). For each essential connectivity area, we will identify a suite of species expected to use the area, and consider ecological processes, functions, and limitations. We will utilize Wildlife Habitat Relationship data (modeled habitat for 700 vertebrate species) or other existing habitat suitability models (e.g., desert tortoise, bighorn sheep) to identify the suite of species that may be served by each essential connectivity area.

Action Step 3.9: Submit essential connectivity areas results to the TAG for review via Data Basin.

Action Step 3.10: Incorporate minor changes based on input from the TAG.

Strategic Action #4: Compare Essential Connectivity Map to other Conservation Maps (October 2009 targeted completion date)

Action Step 4.1: Compare results to other conservation and pertinent maps. We will overlay the results of the analyses to delineate natural landscape blocks and essential connectivity areas with other conservation plans and assess differences. Maps used for these comparisons may include those identified in:

- Missing Linkages (Penrod et al. 2001; statewide arrows based on expert opinion)
- Existing regional linkage plans prepared by various academic or non-profit organizations (Davis and Cohen 2008)
- Conservation priority areas or portfolios identified by TNC
- Digitally available reserve designs for NCCPs, HCPs, and MSCPs
- Critical habitat designated by USFWS for threatened or endangered species, as well as Essential Habitat identified by USFWS for Federally listed species
- Protected Lands (even though protected lands will be used as input to model, this overlay will show hard line boundaries of public/private conservation lands)
- Bay area focus priority conservation areas developed by CBI
- California Rangeland Conservation Coalition Focus Area Prioritization map
- Predictive models of climate change
- Multi-taxa genetic landscapes (Vandergast et al., 2008)

We will discuss compatibility with other statewide plans (e.g., regional transportation plans, State Wildlife Action Plan) and online databases.

Action Step 4.2: Provide comparison summary to the TAG.

Strategic Action #5: Describe Relative Biological Value of Connectivity Areas (November 2009 targeted completion date)

The goal of this strategic action is to describe the mapped linkages according to their *biological value*. The values assigned are emphatically *not* intended to set agendas for any regulatory, management, or conservation entity. Rather the assigned values of each linkage are intended to serve the following limited purposes:

- Each agency can use these description of statewide biological value as one of several inputs into their own prioritization scheme. The agency will continue to set its own priorities based on its particular mission.
- CDFG, Caltrans, or another state or regional entity can voluntarily allocate planning resources for development of fine-scale linkage conservation plans, modification of the SWAP, or development of a new NCCP or HCP.
- To allow agencies and conservation planners to focus conservation or mitigation in particular areas of high biological importance.
- To provide public information that can highlight essential connectivity areas in California.

Action Step 5.1: Select and calculate metrics for biological value of essential connectivity areas. We will use at least the following criteria:

- size of each natural landscape block associated with the essential connectivity area
- ecological integrity of the essential connectivity areas
- fraction or area of the natural landscape blocks and essential connectivity areas in protected status
- a metric derived from graph theory called the "integral index of connectivity" that integrates landscape value (e.g., ecological integrity) and graph connectedness into a single measure (Pascual-Hortal and Suarta 2008).

Several additional metrics for biological value of an essential connectivity area were proposed by members of the TAG. Any metric must meet the following two criteria (1) it must be calculated from *unambiguous, existing* data, and (2) the appropriate data must be available *for the entire analysis area* (State of California plus buffer). We will attempt to find data layers meeting these standards for the following proposed metrics:

- Presence of aquatic features (streams, lakes, wetlands, etc.)
- Irreplaceability (e.g., rarity hotspots from CNDDB)
- Number of life zones (or magnitude of elevation gradients)
- Number of taxa potentially supported (from previous strategic action)
- Importance as migration route (existing or restorable)

Rather than assign relative weights to each metric, we will provide a matrix of scores for each metric by essential connectivity area. The matrix will also identify which ecoregion(s) and which county(s) the essential connectivity area falls within. Subject to input from the TAG, we may classify the relative importance of each area to biodiversity protection in two or more classes (e.g., truly essential vs. important) and if possible, further identify conservation potential (e.g., contribution to existing conservation investments, land condition, restoration opportunities) to assist agencies in prioritizing actions.

Action Step 5.2: Provide Draft Results to the TAG. Provide results of draft analyses for Assigning Biological Value to Connectivity Areas via Data Basin for TAG review and input. Include summary document.

Action Step 5.3: Hold Second Meeting with the TAG to discuss results of analyses for natural landscape blocks, essential connectivity areas, and biological value of connectivity areas (anticipated for October 14 or 15, 2009).

Action Step 5.4: Revise Analyses based on input from the TAG and provide results to the TAG for final review and input.

Action Step 5.5: Address Final Revisions.

Strategic Action #6: Strategic Plan Development (December 2009 targeted completion date)

The goal of this strategic action is to produce a strategic plan that will guide future regional and fine scale connectivity analyses, planning, and implementation.

Action Step 6.1: Circulate strategic plan outline. Provide detailed outline for Strategic Plan to MDT for review and input. Topics likely addressed include:

- Describe goals of the Strategic Plan.
- Summarize methods and results of the preceding analyses, including their limitations.
- Describe steps required to complete ecoregional level analyses.
- Describe steps required to complete local-scale analyses.
- Describe strategies for integrating essential connectivity areas into other planning and implementation strategies (e.g., General Plans, transportation plans, NCCP plans).
- Compare this approach with that of other plans.
- Describe necessary coordination and collaboration efforts.
- Describe threats and opportunities for implementation, including strategies for rating threats (e.g., development, climate change, fires, pests) and opportunities (e.g., state and regional transportation plans).
- Describe climate change assumptions and recommend future scenario analyses.
- Describe how to integrate results into transportation and land use models.

Action Step 6.2: Draft strategic plan. Develop full draft of Strategic Plan based on input received from MDT.

Strategic Action #7: Project Wrap-up (February 2010 targeted completion date)

Action Step 7.1: Develop presentation(s) summarizing the project and how to use the products.

Action Step 7.2: Obtain input from MDT on distribution list for final products.

Action Step 7.3: Hold final meeting with full MDT. Provide all products produced to date. Use meeting to get input on strategic plan (e.g., framework to use products) before finalizing.

Action Step 7.4: Circulate draft strategic plan to full MDT for review and input.

Action Step 7.5: Revise draft strategic plan based on input from MDT.

Action Step 7.6: Circulate final strategic plan to full MDT.

Action Step 7.7: Distribute final products. Compile and distribute final products to comprehensive distribution list.

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Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
1	Rand Mountains - Piute Mountains/ Scodie Mountains	750	576	1,329	192	753	74	37	12,733	52	183	201	172, 186	100	1,097	78	19	58	22	166	2	3	6	0	14	1	0	0	0	0
2	Rand Mountains - Piute Mountains/ Scodie Mountains	932	692	1,101	71	409	74	31	16,485	67	176	183	170, 171, 172, 186, 190	100	125	92	92	0	8	160	2	0	2	0	13	1	0	0	0	1
3	Rand Mountains - Piute Mountains/ Scodie Mountains	946	681	1,061	48	380	65	39	7,438	30	201	214		108	156	89	14	76	11	172	5	6	10	15	0	0	0	0	0	1
4	North Table Mountain - Ishi Wilderness	399	58	1,016	192	958	51	37	244,242	988	625	695	620, 622, 627, 628, 636, 638, 648, 655, 656, 682, 691	32,324	53,109	15	10	4	85	269	11	22	15	0	3	2	5	1	3	2
5	Martin Hill - Butte Valley	1,685	858	2,521	290	1,663	59	32	91,572	371	827	834	828, 830	20,613	30,585	62	3	59	38	257	13	9	6	0	39	1	0	0	4	1
6	Grizzly Mountain - Cottonwood Peak	1,681	1,106	2,545	228	1,439	67	27	113,385	459	654	662	666	23,101	29,296	95	1	94	5	228	5	6	5	0	0	0	0	0	2	0
7	Big Cliff Mine - McConaughy Gulch	1,313	737	2,284	350	1,547	57	30	21,769	88	811	818	843	8,461	9,383	31	12	19	69	230	9	10	6	0	29	1	0	0	2	0
8	Cinder Butte - Popcorn Cave	1,184	974	1,571	115	597	62	34	15,025	61	736	746	745	2,700	4,559	81	0	81	19	263	13	3	4	0	5	1	5	1	2	1
9	Las Colinas/ South Dome - Kettleman Hills	141	89	225	33	136	80	34	47,399	192	248	273	255, 263	15,328	29,631	0	0	0	100	197	6	2	11	0	0	0	0	0	0	2
10	Kern National Wildlife Refuge - Dudley Ridge	60	58	67	2	9	37	44	26,147	106	238	256	235, 243, 251	18,553	23,707	0	0	0	100	200	7	1	12	0	0	0	0	0	5	0
11	McKittrick Valley - Pixley National Wildlife Refuge	64	58	69	2	11	3	12	13,523	55	254	265		2,968	5,655	1	1	0	99	198	2	0	8	0	2	1	2	1	5	0
12	McKittrick Valley - Pixley National Wildlife Refuge	64	60	69	2	9	54	44	30,203	122	238	254	235, 243, 251	11,012	16,226	16	1	15	84	200	3	2	12	0	0	0	0	0	5	0
13	Gravelly Ford Canal - Lone Willow	48	41	62	3	21	34	40	23,112	94	320	329	324	10,072	13,680	0	0	0	100	211	3	6	2	0	0	0	0	0	54	0
14	Eastman Lake NRA - Bear Creek	65	27	218	30	191	34	41	86,695	351	336	346	335, 338, 341, 343	35,461	48,768	19	11	8	81	217	9	14	17	0	36	8	38	1	39	1
15	Ortigalita Ridge/ San Luis Reservoir - Kesterson National Wildlife Refuge	122	22	1,026	116	1,004	43	40	75,196	304	340	348	401	9,330	14,926	46	33	13	54	223	9	8	24	0	2	2	46	3	14	3
16	Bear Slough - Browns Creek	21	0	61	12	61	34	32	30,686	124	466	494	473, 476, 484	21,708	26,577	34	33	1	66	225	2	3	12	0	19	4	16	1	36	1
17	Colusa National Wildlife Refuge - Sacramento National Wildlife Refuge/ Provident Main Canal	19	11	31	3	20	41	41	33,752	137	588	621	601, 610, 616	25,515	29,104	73	72	1	27	220	3	9	6	0	0	0	6	1	43	2
18	Orland Buttes/ Stone Valley/ Julian Rocks - Ishi Wilderness	105	43	362	49	319	51	38	145,800	590	660	695	657, 661, 663, 664, 668, 672, 678, 682, 684, 692	31,107	37,997	12	6	6	88	219	8	19	30	0	12	7	23	1	37	2
19	McClure Creek - Table Mountain	132	77	300	31	223	58	38	68,336	277	681	706	684, 688, 690, 693, 698, 705	24,486	26,106	6	5	1	94	224	8	7	9	0	40	3	40	1	21	2
20	Mt Shasta - Wadsworth Flat	1,471	868	2,458	360	1,590	60	29	38,089	154	808	827	828	2,233	10,793	48	0	47	52	270	17	9	8	0	0	1	0	0	0	1
21	Mt Shasta - Wadsworth Flat	1,113	644	2,459	313	1,815	71	29	70,044	283	827	844	828, 832, 836	13,010	18,068	17	0	17	83	261	10	7	7	0	11	1	0	0	0	0

Characteristics of Essential Connectivity Areas

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
1	0	0.0	22	0.4	1	MOJAVE DESERT	2	Searles Valley-Owlshead Mountains, High Desert Plains and Hills	1	FREMONT	17	1	Kern	0	60	0	4	0	3	0	0	33
2	1	0.0	51	0.8	1	MOJAVE DESERT	1	High Desert Plains and Hills	3	ANTELOPE, CUDDEBACK, FREMONT	84	2	San Bernardino, Kern	0	90	0	0	0	3	0	0	7
3	37	1.2	10	0.4	2	MOJAVE DESERT, SIERRA NEVADA	3	Eastern Slopes, Searles Valley-Owlshead Mountains, High Desert Plains and Hills	3	FREMONT, INDIAN WELLS, KERN RIVER	2	1	Kern	0	88	0	1	0	9	0	0	3
4	32	0.0	309	0.3	3	SIERRA NEVADA, GREAT CENTRAL VALLEY, MODOC PLATEAU	6	North Valley Alluvium, Hardpan Terraces, Shignletown-Paradise, Granitic and Metamorphic Foothills, Tuscan Flows, Lower Foothills Metamorphic Belt	5	BUTTE CREEK, COLUSA BASIN, EASTERN TEHAMA, FEATHER RIVER, TEHAMA	3	2	Tehama, Butte	19	63	3	7	2	6	1	0	0
5	8	0.0	0	0.0	1	MODOC PLATEAU	4	Old Cascades, Shasta Valley, High Cascade, Medicine Lake Lava Flows	1	KLAMATH RIVER	0	1	Siskiyou	75	7	1	4	0	1	5	2	4
6	0	0.0	41	0.1	1	SIERRA NEVADA	4	Diamond Mountains-Crystal Peak, Fredonyer Butte-Grizzly Peak, Frenchman, Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	88	6	0	4	0	0	0	0	1
7	0	0.0	22	0.3	1	NORTH COAST	4	Scott Bar Mountain, Upper Salmon Mountains, Scott Valley, Forks of Salmon	1	KLAMATH RIVER	0	1	Siskiyou	77	3	4	1	0	5	3	0	7
8	1	0.0	11	0.2	1	MODOC PLATEAU	2	Hat Creek Rim, Bald Mountain-Dixie Valley	1	PIT RIVER	0	1	Shasta	32	55	0	1	0	1	6	4	1
9	9	0.1	24	0.1	1	GREAT CENTRAL VALLEY	2	Antelope Plain, Kettleman Hills and Valleys	1	SOUTH VALLEY FLOOR	0	2	Kings, Kern	0	0	88	0	1	4	5	0	2
10	0	0.0	9	0.1	1	GREAT CENTRAL VALLEY	2	Tulare Basin, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	2	Kings, Kern	0	0	3	5	7	3	69	13	0
11	0	0.0	8	0.2	1	GREAT CENTRAL VALLEY	2	Granitic Alluvial Fans and Terraces, Tulare Basin	1	SOUTH VALLEY FLOOR	0	1	Tulare	0	0	4	0	1	5	49	42	0
12	0	0.0	24	0.2	1	GREAT CENTRAL VALLEY	2	Tulare Basin, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	3	Tulare, Kings, Kern	0	0	2	0	3	4	48	42	0
13	0	0.0	23	0.3	1	GREAT CENTRAL VALLEY	1	Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	37	3	0	6	23	30	0
14	14	0.0	81	0.2	1	GREAT CENTRAL VALLEY	5	Hardpan Terraces, Manteca-Merced Alluvium, San Joaquin Basin, Granitic Alluvial Fans and Terraces, Lower Foothills Metamorphic Belt	3	AHWAHNEE, MARIPOSA, SAN JOAQUIN VALLEY FLOOR	0	3	Mariposa, Madera, Merced	0	1	32	8	0	4	43	11	0
15	82	0.3	36	0.1	2	CENTRAL COAST, GREAT CENTRAL VALLEY	5	Westside Alluvial Fans and Terraces, San Joaquin Basin, Western Diablo Range, Diablo Range, Eastern Hills	2	DELTA-MENDOTA CANAL, MIDDLE WEST SIDE	0	1	Merced	1	6	32	11	8	7	25	10	0
16	9	0.1	53	0.4	1	GREAT CENTRAL VALLEY	3	Hardpan Terraces, Sodic Claypan Terraces, Camanche Terraces	3	NORTH VALLEY FLOOR, SACRAMENTO DELTA, SAN JOAQUIN DELTA	2	2	Sacramento, San Joaquin	0	1	52	7	0	7	20	14	0
17	18	0.1	39	0.3	1	GREAT CENTRAL VALLEY	2	North Valley Alluvium, Colusa Basin	1	COLUSA BASIN	0	2	Glenn, Colusa	0	5	22	24	1	4	44	0	0
18	37	0.1	146	0.3	3	GREAT CENTRAL VALLEY, MODOC PLATEAU, NORTH COAST	5	North Valley Alluvium, Western Foothills, Tehama Terraces, Shignletown-Paradise, Tuscan Flows	5	COLUSA BASIN, CORTINA, EASTERN TEHAMA, STONY CREEK, TEHAMA	0	3	Tehama, Butte, Glenn	0	11	56	4	2	4	14	9	0
19	23	0.1	105	0.4	3	GREAT CENTRAL VALLEY, MODOC PLATEAU, NORTH COAST	3	North Valley Alluvium, Tehama Terraces, Tuscan Flows	2	REDDING, TEHAMA	3	1	Tehama	0	29	59	2	1	8	1	1	0
20	9	0.1	8	0.1	1	MODOC PLATEAU	3	Old Cascades, Shasta Valley, High Cascade	3	KLAMATH RIVER, MC CLOUD RIVER, UPPER SACRAMENTO	0	1	Siskiyou	81	11	0	2	0	2	0	0	3
21	0	0.0	24	0.1	2	MODOC PLATEAU, NORTH COAST	4	Scott Bar Mountain, Old Cascades, Shasta Valley, High Cascade	1	KLAMATH RIVER	0	1	Siskiyou	51	41	0	5	0	1	1	1	0

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
22	Gold Bluffs - Siskiyou Mountains	330	0	1,564	257	1,564	61	31	112,221	454	840	848	825, 831, 846, 850	100	108	22	14	8	78	250	16	36	21	7	14	2	0	0	1	2
23	Gold Bluffs - Siskiyou Mountains	878	1	1,873	355	1,872	64	29	91,527	370	847	848	850	5,908	7,691	84	24	60	16	225	3	39	14	29	22	2	0	0	0	2
24	Bald Hills - Castle Crags	818	718	986	67	268	77	11	19,339	78	795	795	789	3,863	5,122	0	0	0	100	242	0	8	10	0	0	1	0	0	0	1
25	Bald Hills - Castle Crags	575	177	1,562	268	1,385	65	31	37,675	152	734	792	735, 737	9,486	12,415	57	28	29	43	256	3	2	12	0	0	0	0	0	0	1
26	Bald Hills - Castle Crags	431	174	1,567	200	1,393	69	24	40,669	165	719	734		8,907	9,776	13	1	12	87	243	14	0	1	0	0	0	12	1	0	0
27	Bald Hills - Castle Crags	517	313	1,312	189	999	81	31	52,147	211	785	792	737, 753, 760, 766, 769	2,892	7,475	89	83	6	11	260	6	3	15	0	0	1	0	0	0	1
28	Noble Ridge/ Beegum Gorge - Salmon Mountains	1,079	417	2,111	242	1,694	68	30	238,867	967	714	815	711, 717, 732, 747, 764, 772	45,045	50,374	73	18	55	27	233	4	15	20	0	24	1	0	0	0	1
29	South Fork Mountain/ Chinquapin Butte - Dairy Ridge/ Pilot Ridge/ South Fork	1,280	758	1,787	261	1,029	62	22	31,743	128	744	783		2,138	2,299	46	0	46	54	235	2	10	13	0	0	2	0	0	0	0
30	South Fork Mountain/ Chinquapin Butte - Dairy Ridge/ Pilot Ridge/ South Fork	1,194	692	1,758	246	1,066	61	30	30,829	125	724	744		1,709	2,210	91	0	91	9	227	1	8	7	0	32	1	0	0	0	0
31	Dairy Ridge/ Pilot Ridge/ South Fork - Redwood Creek/ Bald Hills	809	112	1,788	310	1,676	70	29	177,233	717	783	820	782, 791, 801, 815, 825	37,594	50,481	41	5	36	59	241	6	17	18	0	27	2	0	0	0	2
32	Charles Mountain - Salmon Mountains	1,014	201	1,914	290	1,713	70	29	326,525	1,321	731	815	724, 744, 764, 772, 783	44,241	59,175	82	23	59	18	232	4	24	26	0	34	2	0	0	0	1
33	Sinkyone - Island Mountain	542	4	1,244	241	1,240	69	28	164,191	664	709	715	679, 699	28,795	39,734	15	10	5	85	252	13	20	9	0	17	2	0	0	0	2
34	Charles Mountain - King Range	627	20	1,753	252	1,733	69	23	14,263	58	725	731		260	2,949	10	0	9	91	238	2	3	0	0	9	2	0	0	0	0
35	Charles Mountain - King Range	370	34	925	175	891	65	26	76,436	309	725	733	726, 730	33,247	782	40	31	8	60	243	6	9	9	0	37	2	0	0	0	1
36	Gube Mountain - Snow Mountain	431	141	1,065	234	924	61	35	56,629	229	600	615		7,295	14,161	27	0	27	73	238	4	10	6	0	0	0	0	0	0	1
37	Gube Mountain - Snow Mountain	438	149	995	119	846	72	28	30,568	124	587	600	580	4,880	7,150	2	2	0	98	248	6	2	4	0	1	1	0	0	0	1
38	Gube Mountain - Snow Mountain	782	294	2,049	277	1,755	70	32	116,492	471	615	642	634, 679	11,930	19,741	55	4	52	45	246	9	12	8	0	7	1	0	0	0	2
39	Lake Marie - The Cedars/ Adams Ridge	364	26	807	137	781	71	30	87,269	353	510	566	529, 541, 548	36,261	40,114	25	17	8	75	252	7	24	12	0	2	2	17	2	0	0
40	Chileno Valley - Sanel Mountain	426	224	956	176	732	50	33	6,132	25	580	600		100	1,361	0	0	0	100	249	7	2	1	0	0	0	0	0	0	1
41	Chileno Valley - Sanel Mountain	214	-2	776	146	778	56	35	195,625	792	527	580	530, 534, 536, 538, 546, 565, 574	69,350	79,538	28	23	4	72	263	19	56	26	29	5	5	7	1	1	1
42	Grizzly Island - Lake Marie	105	0	682	111	682	19	24	58,437	236	482	510	474, 489	4,904	10,533	22	16	6	78	259	8	18	18	17	17	8	49	2	17	3

Characteristics of Essential Connectivity Areas

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
22	94	0.2	20	0.0	1	NORTH COAST	6	Northern Franciscan, Western Jurassic, Gasquet Mountain Ultramafics, Siskiyou Mountains, Eastern Franciscan, Central Franciscan	3	KLAMATH RIVER, REDWOOD CREEK, SMITH RIVER	0	3	Del Norte, Siskiyou, Humboldt	82	5	1	2	1	6	0	0	3
23	45	0.1	0	0.0	1	NORTH COAST	7	Northern Franciscan, Western Jurassic, Gasquet Mountain Ultramafics, Siskiyou Mountains, Scott Bar Mountain, Lower Salmon Mountains, Windy Peak	3	KLAMATH RIVER, ROGUE RIVER, SMITH RIVER	0	2	Del Norte, Siskiyou	88	4	0	1	0	5	0	0	2
24	15	0.2	15	0.2	2	MODOC PLATEAU, NORTH COAST	2	Eastern Klamath Mountains, Upper Scott Mountains	2	MC CLOUD RIVER, UPPER SACRAMENTO	0	2	Siskiyou, Shasta	71	0	0	0	0	0	0	0	29
25	9	0.1	9	0.1	2	MODOC PLATEAU, NORTH COAST	2	Oregon Mountain, Eastern Klamath Mountains	3	MOUNTAIN GATE, SHASTA BALLY, SHASTA DAM	0	1	Shasta	44	42	1	1	7	4	0	0	1
26	0	0.0	38	0.2	1	NORTH COAST	4	Oregon Mountain, Eastern Klamath Mountains, Western Foothills, Tehama Terraces	2	REDDING, SHASTA BALLY	0	1	Shasta	19	57	16	1	0	4	0	0	2
27	39	0.2	45	0.2	2	MODOC PLATEAU, NORTH COAST	1	Eastern Klamath Mountains	4	MC CLOUD RIVER, MOUNTAIN GATE, SHASTA DAM, UPPER SACRAMENTO	0	1	Shasta	78	5	0	2	12	3	0	0	0
28	36	0.0	87	0.1	1	NORTH COAST	8	Oregon Mountain, Eastern Klamath Mountains, Upper Scott Mountains, Forks of Salmon, North Trinity Mountain, Trinity Mountain-Hayfork, Rattlesnake Creek, Western Foothills	3	KLAMATH RIVER, SHASTA BALLY, TRINITY RIVER	0	4	Siskiyou, Trinity, Shasta, Tehama	76	16	1	0	0	4	0	0	3
29	0	0.0	0	0.0	1	NORTH COAST	3	Rattlesnake Creek, Eastern Franciscan, Central Franciscan	2	MAD RIVER, TRINITY RIVER	0	2	Humboldt, Trinity	93	1	0	0	0	1	0	0	4
30	0	0.0	13	0.1	1	NORTH COAST	2	Rattlesnake Creek, Eastern Franciscan	2	MAD RIVER, TRINITY RIVER	0	1	Trinity	85	5	0	0	0	4	0	0	7
31	34	0.1	37	0.1	1	NORTH COAST	5	Northern Franciscan, Central Franciscan, Western Jurassic, Rattlesnake Creek, Eastern Franciscan	5	KLAMATH RIVER, MAD RIVER, REDWOOD CREEK, TRINIDAD, TRINITY RIVER	4	2	Humboldt, Trinity	89	5	1	0	0	2	0	0	2
32	40	0.0	50	0.0	1	NORTH COAST	8	Central Franciscan, Oregon Mountain, Upper Scott Mountains, Forks of Salmon, North Trinity Mountain, Trinity Mountain-Hayfork, Rattlesnake Creek, Eastern Franciscan	4	EEL RIVER, KLAMATH RIVER, MAD RIVER, TRINITY RIVER	0	3	Siskiyou, Humboldt, Trinity	88	5	0	0	0	3	0	0	3
33	42	0.1	67	0.1	1	NORTH COAST	2	Central Franciscan, Coastal Franciscan	3	CAPE MENDOCINO, EEL RIVER, MENDOCINO COAST	4	3	Humboldt, Trinity, Mendocino	77	8	1	0	0	5	0	0	9
34	0	0.0	11	0.2	1	NORTH COAST	2	Central Franciscan, Coastal Franciscan	2	CAPE MENDOCINO, EEL RIVER	0	2	Humboldt, Trinity	77	12	3	0	0	1	0	0	8
35	28	0.1	42	0.1	1	NORTH COAST	2	Central Franciscan, Coastal Franciscan	2	CAPE MENDOCINO, EEL RIVER	3	1	Humboldt	87	4	2	0	1	3	0	0	2
36	18	0.1	21	0.1	1	NORTH COAST	2	Central Franciscan, Clear Lake Hills and Valleys	2	CACHE CREEK, RUSSIAN RIVER	0	2	Mendocino, Lake	20	51	18	0	0	6	3	0	2
37	14	0.1	4	0.0	1	NORTH COAST	2	Coastal Franciscan, Central Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	0	1	Mendocino	59	27	8	0	0	4	0	0	2
38	24	0.1	87	0.2	1	NORTH COAST	3	Eastern Franciscan, Central Franciscan, Clear Lake Hills and Valleys	4	CACHE CREEK, EEL RIVER, RUSSIAN RIVER, STONY CREEK	0	4	Mendocino, Glenn, Lake, Colusa	42	45	5	1	0	5	1	0	2
39	0	0.0	63	0.2	2	CENTRAL COAST, NORTH COAST	5	Suisun Hills and Valleys, Mount St. Helena Flows and Valleys, Central Franciscan, Ultramafic Complex, Western Foothills	3	PUTAH CREEK, SAN PABLO, SUISUN	8	2	Napa, Solano	18	67	9	1	1	2	1	0	1
40	10	0.4	0	0.0	1	NORTH COAST	2	Coastal Franciscan, Central Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	0	1	Mendocino	38	31	18	0	0	9	0	0	3
41	32	0.0	176	0.2	2	CENTRAL COAST, NORTH COAST	4	Coastal Franciscan, Coastal Hills-Santa Rosa Plain, Marin Hills and Valleys, Central Franciscan	4	BODEGA, MARIN COASTAL, MENDOCINO COAST, RUSSIAN RIVER	1	3	Mendocino, Sonoma, Marin	41	25	26	1	1	4	0	0	3
42	55	0.2	74	0.3	3	CENTRAL COAST, GREAT CENTRAL VALLEY, NORTH COAST	4	Suisun Hills and Valleys, Delta, Mount St. Helena Flows and Valleys, Ultramafic Complex	2	SAN PABLO, SUISUN	0	2	Napa, Solano	1	15	48	14	1	12	5	1	1

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
43	Tolay Creek - Lake Marie	25	0	504	63	504	27	30	32,618	132	504	510	486, 498	19,228	22,301	47	35	12	53	258	7	15	22	0	3	3	18	2	23	3
44	Sugarloaf Mountain - Bonny Doon	163	5	442	86	437	9	28	25,969	105	347	350	374	14,838	17,864	37	33	4	63	280	16	23	20	0	23	4	28	2	0	2
45	Sugarloaf Mountain - Montara Mountain	331	1	1,154	200	1,153	36	36	345,662	1,399	347	411	345,349,357,361,365,366,374,376,377, 378,385,395,3*	61,323	74,337	40	24	16	60	273	11	68	41	33	10	8	66	2	0	6
46	Pancho Rico Valley - Pinnacles National Monument	370	83	811	122	728	75	32	190,302	770	283	321	287, 291, 296, 297, 298, 300, 301, 316	38,928	42,717	1	1	0	99	223	11	7	18	0	26	3	25	2	0	1
47	San Geronimo - Weferling Canyon	370	139	892	120	753	70	31	110,849	449	242	281	247, 257, 262, 268, 271, 272, 314	50,085	55,629	30	12	18	70	241	11	23	8	0	1	1	9	3	0	0
48	Pancho Rico Valley - Los Padres National Forest	357	85	1,005	150	920	66	35	259,671	1,051	283	314	272, 281, 286, 287, 291, 294	34,227	37,862	30	0	30	70	234	13	38	23	0	0	1	5	3	0	3
49	Riverside Mountains - Pinto Basin/ Eagle Mountain	272	116	421	35	305	97	12	67,112	272	62	67	60	19,361	21,054	98	67	31	2	169	16	2	4	0	0	0	0	0	0	0
50	Riverside Mountains - Pinto Basin/ Eagle Mountain	245	153	687	66	534	85	30	33,766	137	67	80		5,869	8,622	96	0	96	4	155	2	3	2	0	0	1	0	0	0	0
51	Chocolate Mountains - Turtle Mountains/ Ward Valley	450	17	1,622	246	1,605	94	20	1,460,957	5,912	50	116	53, 57, 60, 67, 72, 80, 86, 90, 91, 92	61,120	130,534	93	63	30	7	157	9	27	22	0	16	1	0	0	0	2
52	San Bernardino Mountains - Calico Mountains	716	581	1,121	107	540	48	42	98,177	397	144	190	149	6,600	18,732	53	19	33	47	165	12	7	10	0	19	1	0	0	0	3
53	San Bernardino Mountains - Calico Mountains	1,265	839	3,029	517	2,190	68	36	146,248	592	101	144	93, 102	12,202	14,395	66	5	61	34	192	47	47	25	23	3	11	0	1	0	1
54	Contract Point - Santa Susana Mountains	608	317	1,138	167	821	14	24	29,349	119	129	136		3,081	3,545	17	7	10	83	263	10	8	10	0	45	1	0	0	0	3
55	Tehachapi Mountains - Piute Mountains/ Scodie Mountains	1,347	190	2,564	430	2,374	79	30	561,941	2,274	179	214	177, 178, 184, 189, 191, 193, 194, 196, 209, 220	42,559	72,157	49	24	25	51	230	26	35	42	36	0	1	0	0	0	2
56	Lone Oak Mountain - Tucker Mountain	371	128	967	163	839	74	33	50,393	204	285	292	290	16,595	18,505	0	0	0	100	247	6	2	6	0	18	2	19	1	2	0
57	Hunter Valley Mountain - Cardoza Ridge	294	108	673	102	565	76	29	28,718	116	367	371		11,148	15,517	8	0	8	92	251	3	1	3	2	1	3	6	2	0	0
58	Flat Top Mountain - Hunter Valley Mountain	407	137	947	153	810	78	32	53,854	218	341	367	343, 351, 359	27,288	29,150	2	0	2	98	247	7	4	2	42	0	0	0	0	0	0
59	Table Top Mountain - Gopher Ridge	120	31	458	69	427	76	32	215,316	871	360	409	358, 371, 372, 379, 380, 381, 382, 389, 390, 404	40,921	53,039	6	6	0	94	232	14	17	30	0	44	10	57	1	38	1

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
43	17	0.1	34	0.3	2	CENTRAL COAST, NORTH COAST	3	Suisun Hills and Valleys, Coastal Hills-Santa Rosa Plain, Mount St. Helena Flows and Valleys	2	SAN PABLO, SUISUN	0	3	Sonoma, Napa, Solano	1	4	59	17	8	7	2	0	2
44	12	0.1	62	0.6	1	CENTRAL COAST	2	Santa Cruz Mountains, Watsonville Plain-Salinas Valley	1	BIG BASIN	0	1	Santa Cruz	43	30	2	1	0	23	1	0	0
45	264	0.2	416	0.3	1	CENTRAL COAST	4	Santa Clara Valley, Santa Cruz Mountains, Leeward Hills, Watsonville Plain-Salinas Valley	5	BIG BASIN, PAJARO RIVER, SAN MATEO, SANTA CLARA, SOUTH BAY	0	3	San Mateo, Santa Clara, Santa Cruz	40	37	4	1	0	16	0	0	0
46	20	0.0	45	0.1	1	CENTRAL COAST	4	Watsonville Plain-Salinas Valley, Diablo Range, Interior Santa Lucia Range, Gabilan Range	1	SALINAS	0	2	San Benito, Monterey	6	40	44	1	0	5	1	2	0
47	0	0.0	46	0.1	1	CENTRAL COAST	3	South Costal Santa Lucia Range, Interior Santa Lucia Range, Paso Robles Hills and Valleys	2	ESTERO BAY, SALINAS	7	2	Monterey, San Luis Obispo	18	43	26	2	5	5	1	0	0
48	62	0.1	94	0.1	1	CENTRAL COAST	6	Watsonville Plain-Salinas Valley, North Costal Santa Lucia Range, South Costal Santa Lucia Range, Interior Santa Lucia Range, Gabilan Range, Paso Robles Hills and Valleys	3	ESTERO BAY, SALINAS, SANTA LUCIA	0	1	Monterey	14	47	22	3	0	6	6	1	1
49	0	0.0	14	0.1	1	SONORAN DESERT	3	Cadiz-Vidal Valleys, Palen-Riverside Mountains, Palo Verde Valley and Mesa	4	CHUCKWALLA, COLORADO, RICE, WARD	0	1	Riverside	0	88	0	3	0	0	0	0	8
50	0	0.0	14	0.1	2	SONORAN DESERT, MOJAVE DESERT	4	Pinto Basin and Mountains, Cadiz-Vidal Valleys, Palen-Riverside Mountains, Chuckwalla Valley	4	CHUCKWALLA, COLORADO, RICE, WARD	0	1	Riverside	0	96	0	0	0	1	0	0	2
51	240	0.0	150	0.0	2	SONORAN DESERT, MOJAVE DESERT	10	Providence Mountains-Lanfair Valley, Lucerne-Johnson Valleys and Hills, Bullion Mountains-Bristol Lake, Pinto Basin and Mountains, Cadiz-Vidal Valleys, Palen-Riverside Mountains, Chuckwalla Valley, Chocolate Mountains and Valleys	12	CADIZ, CHEMEHUEVIS, CHUCKWALLA, COLORADO, DALE, EAST SALTON, HAYFIELD, IMPERIAL, RICE, ROUTE SIXTY SIX, WARD, WHITEWATER	8	3	San Bernardino, Riverside, Imperial	0	57	0	6	0	1	0	0	36
52	112	0.3	151	0.4	1	MOJAVE DESERT	3	High Desert Plains and Hills, Mojave Valley-Granite Mountains, Lucerne-Johnson Valleys and Hills	3	COYOTE, MOJAVE, SUPERIOR	19	1	San Bernardino	0	68	0	1	0	11	0	0	19
53	1	0.0	98	0.2	3	SONORAN DESERT, SOUTH COAST, MOJAVE DESERT	4	San Gorgonio Mountains, Upper San Gorgonio Mountains, Little San Bernardino-Bighorn Mountains, Lucerne-Johnson Valleys and Hills	8	EMERSON, JOHNSON, JOSHUA TREE, LUCERNE LAKE, MEANS, MOJAVE, SANTA ANA RIVER, WHITEWATER	1	2	San Bernardino, Riverside	18	61	4	0	0	3	0	0	13
54	40	0.3	32	0.3	1	SOUTH COAST	4	Simi Valley-Santa Susana Mountains, Los Angeles Plain, Sierra Pelona-Mint Canyon, San Gabriel Mountains	3	CALLEGUAS, LOS ANGELES RIVER, SANTA CLARA - CALLEGUAS	0	2	Ventura, Los Angeles	1	75	10	1	0	14	0	0	0
55	83	0.0	253	0.1	4	SOUTH COAST, MOJAVE DESERT, SIERRA NEVADA, GREAT CENTRAL VALLEY	9	Hardpan Terraces, South Valley Alluvium and Basins, Lower Batholith, Eastern Slopes, Tehachapi-Piute Mountains, Southern Granitic Foothills, San Emigdio Mountains, High Desert Plains and Hills	6	ANTELOPE, FREMONT, GRAPEVINE, KERN RIVER, SOUTH VALLEY FLOOR, SOUTHERN SIERRA	1	1	Kern	34	55	7	2	0	1	0	0	1
56	0	0.0	32	0.2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Hardpan Terraces, Lower Granitic Foothills	2	KAWEAH RIVER, SOUTH VALLEY FLOOR	0	1	Tulare	0	41	49	3	0	2	4	1	0
57	0	0.0	11	0.1	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Camanche Terraces, Lower Foothills Metamorphic Belt	3	MARIPOSA, MERCED RIVER, SAN JOAQUIN VALLEY FLOOR	0	2	Mariposa, Merced	0	58	29	5	5	2	0	0	0
58	0	0.0	43	0.2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Lower Foothills Metamorphic Belt, Lower Granitic Foothills	2	MARIPOSA, MERCED RIVER	0	1	Mariposa	1	56	35	6	0	1	0	0	1
59	32	0.0	164	0.2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	4	Hardpan Terraces, Camanche Terraces, Manteca-Merced Alluvium, Lower Foothills Metamorphic Belt	6	GOPHER RIDGE, MERCED RIVER, NORTH VALLEY FLOOR, SAN JOAQUIN VALLEY FLOOR, STANISLAUS RIVER, TUOLUMNE RIVER	0	4	Calaveras, Tuolumne, Stanislaus, Merced	0	10	69	7	3	3	6	3	0

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
60	Pine Ridge - Irish Hill	464	77	943	240	866	49	33	142,325	576	454	479	445, 452, 455, 457, 463, 469, 477, 485	34,874	42,556	10	0	9	90	250	14	8	5	0	0	0	2	1	0	2
61	Bear Mountains - Middle Fork Cosumnes River	582	286	738	73	452	53	31	13,119	53	485	511	492, 493	2,583	3,321	0	0	0	100	269	7	0	0	0	0	0	68	1	2	0
62	Bear Mountains - Middle Fork Cosumnes River	433	169	808	125	639	45	30	88,346	358	435	485	439, 443, 445, 452, 455, 457	26,745	29,968	4	0	4	96	257	11	4	4	0	0	0	9	1	0	3
63	Duck Creek North Fork - Coyote Creek	71	46	148	16	102	52	35	1,362	6	471	494		100	106	19	19	0	81	226	1	2	4	0	52	4	81	1	65	0
64	Duck Creek North Fork - Coyote Creek	58	22	123	16	101	53	35	15,641	63	442	471	450, 461	4,963	7,473	1	1	0	99	232	4	2	9	0	20	4	0	1	22	1
65	Duck Creek North Fork - Coyote Creek	56	37	98	17	61	35	38	5,159	21	425	442	427	1,700	3,071	0	0	0	100	221	1	0	6	0	11	2	3	1	4	0
66	Duck Creek North Fork - Coyote Creek	71	28	160	27	132	41	32	27,301	110	494	522	491, 505, 523, 525	3,912	10,404	16	14	3	84	243	10	5	10	0	0	3	41	2	6	0
67	Coon Creek - Bear River	90	24	431	66	407	54	28	39,501	160	555	563	557, 562	13,113	18,090	8	8	0	92	244	8	3	6	0	6	1	25	1	25	1
68	Chaparral Hill/ Yuba River - Bald Mountain Range	1,052	159	2,074	474	1,915	50	29	69,755	282	590	595	577, 583, 602	16,603	21,930	42	8	33	58	221	21	9	7	0	3	1	0	1	0	1
69	Chaparral Hill/ Yuba River - Bald Mountain Range	1,957	1,232	2,690	234	1,458	59	31	185,076	749	595	613	597, 602	16,882	38,772	69	5	65	31	215	23	16	22	0	0	0	0	0	6	1
70	Fort Sage Mountains - Cottonwood Peak	1,619	1,214	2,184	271	970	67	33	96,094	389	647	662	649, 652	27,136	35,290	68	2	67	32	266	26	11	3	0	0	0	0	0	2	1
71	Grizzly Mountain - Deadwood Canyon	1,423	840	2,242	289	1,402	60	31	50,069	203	654	665	650, 658, 666	15,568	17,864	81	0	81	19	222	8	13	5	0	0	0	0	1	0	1
72	Big Bar Mountain/ Stevens Ridge - Ishi Wilderness	1,355	280	2,391	385	2,111	66	27	474,721	1,921	655	695	641, 645, 656, 665, 667, 682, 685, 691, 698	29,705	40,346	53	18	35	47	229	20	38	24	0	0	0	13	1	1	1
73	Table Mountain - Lassen Volcanic Wilderness	1,044	105	2,979	503	2,874	58	29	127,115	514	706	710	700, 705, 707	34,493	35,262	21	11	10	79	246	19	35	25	0	6	2	6	1	5	1
74	Pilot Butte - Knox Mountain	1,565	1,266	2,246	229	980	58	32	71,928	291	768	779	757, 770, 773	18,974	25,694	58	0	58	42	262	4	5	6	0	0	0	0	0	2	2
75	McCloud River/ Curl Ridge - McConaughy Gulch	1,503	350	2,747	455	2,397	70	28	189,891	768	785	818	789, 795, 799, 806	52,627	56,596	54	15	39	46	232	12	37	24	0	18	1	0	0	1	1
76	Beaver Creek Rim/ Indian Mountain - Little Hot Spring Valley	1,346	1,002	1,838	207	836	59	31	92,073	373	742	774	752	18,496	23,627	40	0	40	60	252	5	5	11	0	0	1	0	1	2	1
77	Warner Mountains - Mount Bidwell/ Larkspur Hills	1,754	1,354	2,571	300	1,217	59	34	300,061	1,214	786	813	738, 797	14,928	43,776	59	6	53	41	252	21	52	26	0	0	0	3	1	8	0

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
60	54	0.1	154	0.3	1	SIERRA NEVADA	4	Camanche Terraces, Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows, Lower Foothills Metamorphic Belt	3	MIDDLE SIERRA, NORTH VALLEY FLOOR, UPPER CALAVERAS	0	2	Amador, Calaveras	30	49	12	5	0	3	0	0	0
61	0	0.0	23	0.4	1	SIERRA NEVADA	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	2	El Dorado, Amador	8	76	0	6	0	3	1	5	0
62	39	0.1	94	0.3	1	SIERRA NEVADA	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	3	LOWER CALAVERAS, MIDDLE SIERRA, UPPER CALAVERAS	0	2	Amador, Calaveras	11	79	0	6	1	4	0	0	1
63	0	0.0	15	2.8	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	2	Sacramento, Amador	0	1	74	1	0	24	0	0	0
64	11	0.2	15	0.2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	4	Sacramento, Amador, Calaveras, San Joaquin	0	7	70	5	2	6	6	3	0
65	0	0.0	15	0.7	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	1	San Joaquin	0	3	38	5	3	8	33	9	0
66	0	0.0	44	0.4	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	3	Hardpan Terraces, Camanche Terraces, Lower Foothills Metamorphic Belt	3	MIDDLE SIERRA, NORTH VALLEY FLOOR, VALLEY-AMERICAN	0	2	Sacramento, Amador	0	21	57	3	2	8	4	4	2
67	9	0.1	39	0.3	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	4	AMERICAN RIVER, BEAR RIVER, MARYSVILLE, VALLEY-AMERICAN	0	3	Yuba, Nevada, Placer	0	27	46	4	1	4	4	15	0
68	8	0.0	42	0.2	1	SIERRA NEVADA	4	Granitic and Metamorphic Foothills, Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	3	Sierra, Yuba, Nevada	65	26	0	6	0	1	0	0	1
69	17	0.0	125	0.2	2	SIERRA NEVADA, MODOC PLATEAU	5	Frenchman, Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Sierra Valley, Tahoe-Truckee	5	FEATHER RIVER, LITTLE TRUCKEE RIVER, SUSANVILLE, TRUCKEE RIVER, YUBA RIVER	0	2	Sierra, Nevada	83	8	0	6	0	1	0	0	0
70	29	0.1	21	0.1	2	SIERRA NEVADA, MODOC PLATEAU	4	Diamond Mountains-Crystal Peak, Frenchman, Fort Sage Mountains-Lemmon Valley, Honey Lake Basin	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	55	38	0	2	0	2	1	1	2
71	18	0.1	22	0.1	1	SIERRA NEVADA	2	Fredonyer Butte-Grizzly Peak, Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	93	2	0	4	0	1	0	0	0
72	45	0.0	412	0.2	3	SIERRA NEVADA, GREAT CENTRAL VALLEY, MODOC PLATEAU	7	North Valley Alluvium, Shignletown-Paradise, Lassen-Almanor, Greenville-Graeagle, Bucks Lake, Granitic and Metamorphic Foothills, Tuscan Flows	4	BUTTE CREEK, EASTERN TEHAMA, FEATHER RIVER, TEHAMA	1	3	Tehama, Plumas, Butte	81	8	0	6	0	2	0	0	3
73	51	0.1	34	0.1	1	MODOC PLATEAU	4	Tehama Terraces, Shignletown-Paradise, Lassen-Almanor, Tuscan Flows	5	EASTERN TEHAMA, FEATHER RIVER, PIT RIVER, REDDING, WHITMORE	0	3	Shasta, Tehama, Plumas	58	32	3	5	0	1	0	0	1
74	14	0.1	29	0.1	1	MODOC PLATEAU	3	Mowitz Buttes, Likely Mountain, Adin Mountains and Valleys	1	PIT RIVER	0	2	Modoc, Lassen	53	36	1	3	0	1	3	3	1
75	21	0.0	40	0.1	2	MODOC PLATEAU, NORTH COAST	4	Scott Valley, Eastern Klamath Mountains, Upper Scott Mountains, Shasta Valley	6	KLAMATH RIVER, MC CLOUD RIVER, PIT RIVER, SHASTA DAM, TRINITY RIVER, UPPER SACRAMENTO	0	3	Siskiyou, Trinity, Shasta	82	12	0	3	0	1	0	0	1
76	17	0.1	21	0.1	1	MODOC PLATEAU	4	Medicine Lake Lava Flows, Hat Creek Rim, Mowitz Buttes, Bald Mountain-Dixie Valley	1	PIT RIVER	0	4	Siskiyou, Modoc, Shasta, Lassen	56	33	0	2	0	1	3	2	2
77	0	0.0	118	0.1	1	MODOC PLATEAU	7	Warner Mountains, Pit River Valley, Likely Mountain, Sheldon Range, Cottonwood-Skedaddle Mountains, Madeline Plain, Surprise Valley	5	DUCK FLAT, LAKEVIEW, MADELINE PLAINS, PIT RIVER, SUPRISE VALLEY	0	2	Modoc, Lassen	51	15	6	7	1	1	4	5	10

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
78	Barber Ridge - Double Head Mountain/ Timbered Ridge	1,501	1,268	1,944	105	676	59	28	140,653	569	773	814	781, 788	23,763	34,777	91	6	86	9	264	5	10	9	0	0	0	8	1	3	1
79	Ord Mountains - Mid Hills/ Ivanpah Valley/ New York Mountains	701	381	1,934	192	1,553	91	23	529,767	2,144	144	159	130, 133, 154, 162	74,537	88,615	97	55	42	3	144	6	22	17	0	0	1	0	0	0	1
80	Mid Hills/ Ivanpah Valley/ New York Mountains - Calico Mountains	755	279	2,049	360	1,770	94	19	1,035,612	4,191	159	190	146, 149, 154, 162, 163, 203	56,196	62,966	95	76	18	5	151	10	39	28	4	32	1	0	0	0	1
81	Calico Mountains - Death Valley/ Black Mountains/ Amargosa Range	745	-57	1,664	360	1,721	96	14	478,764	1,937	190	253	269	68,645	88,376	99	53	46	1	142	5	3	8	0	1	1	0	0	0	0
82	Silver Mountain/ Rose Valley - Death Valley/ Panamint Range	1,339	-81	2,538	525	2,619	95	19	417,627	1,690	260	269	253, 258, 264, 267, 310	53,963	83,271	100	92	8	0	153	13	35	10	10	0	0	0	0	0	0
83	Silver Mountain/ Rose Valley - Inyo Mountains/ Saline Valley/ Death Valley	1,610	1,338	2,353	285	1,015	86	29	13,508	55	260	267		3,457	4,364	97	1	96	3	162	8	2	1	0	0	0	0	0	0	0
84	Silver Mountain/ Rose Valley - Inyo Mountains/ Saline Valley/ Death Valley	2,006	329	2,884	261	2,555	95	17	21,873	89	267	310		2,236	2,582	96	1	95	4	176	16	10	1	0	0	0	0	0	0	0
85	Lone Oak Mountain - Redwood Mountain/ Pine Ridge	620	150	2,446	318	2,296	87	22	41,566	168	285	293	375	16,677	17,398	17	13	4	83	250	8	5	14	0	4	2	5	1	0	1
86	Anticline Ridge - Joaquin Ridge	363	136	1,475	248	1,339	45	41	70,772	286	282	306	316	8,439	12,572	11	7	5	89	215	9	12	17	0	0	0	4	2	0	3
87	San Luis Canal - Kesterson National Wildlife Refuge	27	21	34	3	13	50	38	38,237	155	333	348	344	11,183	16,354	99	45	54	1	220	4	8	14	0	1	4	1	1	76	1
88	Cherokee Creek - Pine Ridge	538	281	967	133	686	59	26	37,817	153	426	454	422, 429, 436	16,424	18,493	13	0	13	87	263	14	2	3	0	0	0	98	1	0	1
89	Marble Valley - Sawtooth Ridge	723	110	2,155	448	2,045	43	37	217,268	879	528	572	525, 542, 543, 547, 549, 552, 554, 558, 559, 567	63,905	83,812	51	21	30	49	232	21	18	24	0	0	0	5	1	0	3
90	Sturdevant Ridge - Mosquito Ridge/ Crystal Ridge	1,661	766	2,701	329	1,935	52	27	171,457	694	517	567	518, 519, 524, 537	21,739	29,201	64	1	62	36	201	12	10	20	0	0	0	12	1	1	1
91	Bear River - Chaparral Hill/ Yuba River	260	67	674	103	607	67	30	46,438	188	563	590	573	19,000	21,878	26	4	21	74	248	3	2	6	0	0	0	0	0	0	1
92	Popcorn Cave - Curl Ridge	998	434	1,786	192	1,352	70	30	182,819	740	746	785	736, 745, 749, 754, 756, 758	49,155	51,269	54	9	45	47	244	10	19	34	0	21	3	1	1	1	2
93	Timbered Crater - Mt Dome	1,622	1,100	2,406	310	1,306	63	29	176,143	713	790	829	794, 796, 805, 810, 817, 819	39,409	44,245	96	20	76	4	242	11	12	11	0	0	0	0	0	0	0
94	Little Cottonwood Pk - Siskiyou Mountains	1,202	523	2,143	382	1,620	57	31	58,755	238	842	847	837	18,381	22,939	58	0	58	42	235	5	5	6	0	4	1	0	0	2	1
95	Big River/ Hi Chute Ridge - Black Oak Mountain	352	8	1,281	202	1,273	62	26	96,961	392	643	686		35,652	39,233	18	2	16	82	253	4	7	8	0	17	2	0	0	0	0

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
78	16	0.0	0	0.0	1	MODOC PLATEAU	4	Devil's Garden, Mowitz Buttes, Pit River Valley, Adin Mountains and Valleys	2	KLAMATH RIVER, PIT RIVER	0	1	Modoc	66	28	2	3	0	0	0	0	1
79	99	0.1	100	0.1	1	MOJAVE DESERT	7	Mojave Valley-Granite Mountains, Silurian Valley-Devil's Playground, Kingston Range-Valley Wells, Ivanpah Valley, Providence Mountains-Lanfair Valley, Lucerne-Johnson Valleys and Hills, Bullion Mountains-Bristol Lake	6	BESSEMER, BROADWELL, LAVIC, LUCERNE LAKE, MOJAVE, ROUTE SIXTY SIX	10	1	San Bernardino	0	59	0	0	0	1	0	0	40
80	194	0.1	181	0.0	1	MOJAVE DESERT	6	Mojave Valley-Granite Mountains, Silurian Valley-Devil's Playground, Kingston Range-Valley Wells, Ivanpah Valley, Providence Mountains-Lanfair Valley, Bullion Mountains-Bristol Lake	8	AMARGOSA, BROADWELL, COYOTE, HOMER, IVANPAH, MOJAVE, ROUTE SIXTY SIX, SUPERIOR	2	1	San Bernardino	0	65	0	1	0	1	0	0	33
81	0	0.0	37	0.0	1	MOJAVE DESERT	5	Death Valley, Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley, Searles Valley-Owlshead Mountains, Mojave Valley-Granite Mountains	9	AMARGOSA, BALLARAT, GOLDSTONE, GRANITE, LEACH, MOJAVE, OWLSHEAD, SUPERIOR, TRONA	0	2	Inyo, San Bernardino	0	40	0	3	0	0	0	0	57
82	0	0.0	145	0.1	2	MOJAVE DESERT, SIERRA NEVADA	8	Owens Valley, Death Valley, Panamint Valley, Searles Valley-Owlshead Mountains, Inyo Mountains, Saline Valley Cottonwood Mountains, Cosa-Argus Ranges, Panamint Range	6	AMARGOSA, BALLARAT, INDIAN WELLS, OWENS, RACE TRACK, SALINE	1	1	Inyo	7	34	0	1	0	1	0	0	57
83	0	0.0	6	0.1	1	MOJAVE DESERT	2	Inyo Mountains, Cosa-Argus Ranges	3	BALLARAT, INDIAN WELLS, OWENS	0	1	Inyo	17	24	0	26	0	1	0	0	32
84	0	0.0	0	0.0	2	MOJAVE DESERT, SIERRA NEVADA	3	Inyo Mountains, Saline Valley-Cottonwood Mountains, Cosa-Argus Ranges	3	BALLARAT, OWENS, SALINE	1	1	Inyo	42	17	0	0	0	0	0	0	41
85	20	0.1	6	0.0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	4	Hardpan Terraces, Lower Batholith, Upper Batholith, Lower Granitic Foothills	2	KAWEAH RIVER, SOUTH VALLEY FLOOR	1	1	Tulare	12	52	31	5	0	0	0	0	0
86	39	0.1	29	0.1	2	CENTRAL COAST, GREAT CENTRAL VALLEY	5	Westside Alluvial Fans and Terraces, Panoche and Cantua Fans and Basins, Diablo Range, Eastern Hills, Kettleman Hills and Valleys	3	COAST RANGE, PAJARO RIVER, SOUTH VALLEY FLOOR	7	2	Fresno, San Benito	4	4	62	0	0	19	10	2	0
87	12	0.1	30	0.2	1	GREAT CENTRAL VALLEY	2	Westside Alluvial Fans and Terraces, San Joaquin Basin	1	DELTA-MENDOTA CANAL	0	1	Merced	0	3	5	63	1	6	12	8	0
88	8	0.1	64	0.4	1	SIERRA NEVADA	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	UPPER CALAVERAS	0	1	Calaveras	17	73	0	7	0	3	0	0	0
89	29	0.0	162	0.2	1	SIERRA NEVADA	4	Hardpan Terraces, Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Lower Foothills Metamorphic Belt	3	AMERICAN RIVER, MIDDLE SIERRA, VALLEY-AMERICAN	1	3	Placer, El Dorado, Sacramento	52	32	4	5	2	4	0	0	1
90	54	0.1	138	0.2	1	SIERRA NEVADA	6	Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Tahoe-Truckee, Glaciated Batholith and Volcanic Flows, Tahoe Valley, Batholith and Volcanic Flows	4	AMERICAN RIVER, LAKE TAHOE, MIDDLE SIERRA, TRUCKEE RIVER	0	2	Placer, El Dorado	84	6	0	5	1	2	0	0	2
91	9	0.1	24	0.1	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	1	Lower Foothills Metamorphic Belt	2	BEAR RIVER, YUBA RIVER	0	3	Yuba, Nevada, Placer	1	85	5	7	1	2	0	0	0
92	42	0.1	81	0.1	1	MODOC PLATEAU	4	Eastern Klamath Mountains, Hat Creek Rim, Shignletown-Paradise, Bald Mountain-Dixie Valley	2	MC CLOUD RIVER, PIT RIVER	0	1	Shasta	75	17	0	3	1	1	1	0	2
93	0	0.0	71	0.1	1	MODOC PLATEAU	5	Medicine Lake Lava Flows, Medicine Lake Highlands, Hat Creek Rim, Mowitz Buttes, Bald Mountain-Dixie Valley	2	KLAMATH RIVER, PIT RIVER	0	1	Siskiyou	81	8	0	0	0	1	0	0	10
94	16	0.1	0	0.0	1	NORTH COAST	2	Scott Bar Mountain, Windy Peak	2	KLAMATH RIVER, ROGUE RIVER	0	1	Siskiyou	85	6	1	1	0	6	0	0	2
95	0	0.0	44	0.1	1	NORTH COAST	2	Coastal Franciscan, Central Franciscan	2	EEL RIVER, MENDOCINO COAST	0	1	Mendocino	86	4	1	0	0	5	0	0	5

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
96	Bonny Doon - Castle Rock	407	73	981	184	908	19	26	60,468	245	350	366	355, 357, 365, 374	17,920	22,905	24	22	1	76	269	3	22	15	0	14	2	8	1	0	1
97	Los Padres National Forest - Pilarcitos Canyon	350	2	1,526	230	1,524	46	39	131,465	532	314	325	302, 304, 311, 317, 319	8,957	18,413	25	14	11	75	262	14	51	25	45	35	4	64	2	0	2
98	San Ynez Mountains West - Casmalia Hills	138	7	489	70	482	45	41	79,399	321	168	202	165, 169, 174, 185	25,416	33,798	10	9	1	90	260	6	24	22	0	3	3	85	5	3	1
99	Castro Peak/Santa Monica Mtns - Pine Mountain/Sespe Condor	402	62	1,304	161	1,242	23	35	119,050	482	107	160	106, 109, 111, 112, 114, 124, 136	36,200	42,675	38	36	2	62	258	8	23	37	0	23	9	27	5	1	4
100	The Badlands West - Box Springs Mountains	620	348	939	93	591	7	15	23,591	95	84	87		13,455	15,928	2	2	1	98	267	3	11	19	100	28	1	0	0	0	0
101	Santa Rosa Mountains - Cahuilla Moutain/Rouse Ridge	1,448	690	2,077	188	1,387	51	36	17,316	70	66	74	76	100	113	75	2	73	25	266	8	18	13	5	0	3	10	2	2	1
102	Santa Rosa Mountains - Cahuilla Moutain/Rouse Ridge	1,293	307	2,642	337	2,335	40	28	14,608	59	59	74	66	100	917	44	5	39	56	248	15	22	10	61	36	1	0	0	0	1
103	Lake Skinner - Cahuilla Moutain/Rouse Ridge	726	511	1,563	133	1,052	47	25	18,980	77	64	66	61	5,248	7,820	5	0	5	95	261	8	8	13	100	28	4	2	2	0	0
104	Canada de San Vicente/Iron Mountain - Black Mountain/Guejito Creek	451	136	872	79	736	24	25	27,102	110	33	46	35, 39	9,707	13,175	30	17	13	70	256	5	21	29	45	11	4	45	7	1	1
105	Palomar Mountains - Camp Pendleton/Santa Rosa	427	49	1,848	209	1,799	24	27	94,989	384	52	68	51, 54, 56, 58	14,566	20,060	21	9	11	79	272	7	52	41	90	20	6	77	9	1	2
106	East Mesa Sand Dunes - Chocolate Mountains South	81	48	515	21	467	100	0	6,560	27	3	6		1,000	1,124	100	0	100	0	163	1	6	1	0	3	1	0	0	0	0
107	East Mesa Sand Dunes - Chocolate Mountains South	157	42	667	76	625	94	19	96,435	390	6	18		18,546	28,706	96	0	96	4	165	5	10	16	0	0	3	0	1	0	0
108	Jacumba Peak - Campo Valley	1,080	832	1,236	61	404	54	31	27,307	111	4	7	5, 11, 31	10,486	14,914	3	0	3	97	245	5	6	6	0	9	2	6	1	1	2
109	McGinty Mountain/Lawson Valley - El Capitan	395	111	1,093	129	982	9	22	29,627	120	19	37	23	9,613	26,926	34	28	6	66	271	7	19	21	50	6	1	18	4	0	1
110	Noble Ridge/ Beegum Gorge - South Fork Mountain/ Chinquapin Butte	1,360	537	2,385	250	1,848	63	30	92,802	376	714	724	717, 720	10,734	15,846	96	19	77	4	229	3	7	8	0	20	1	0	0	0	0
111	Salmon Mountains - Redwood/ Williams Ridge/ Holter Ridge	712	17	1,811	361	1,794	64	30	99,062	401	815	825	809, 811, 848	12,200	22,807	52	2	50	48	232	6	14	17	0	26	2	0	0	0	1
112	Mill Creek Rim - Lassen Volcanic Wilderness	1,795	744	3,169	318	2,425	61	29	97,957	396	691	710	707	11,323	14,703	71	23	48	29	218	10	32	19	0	0	0	0	0	5	2
113	Pine Ridge - Lightning Mountain	1,652	798	2,733	291	1,935	46	34	65,625	266	454	470	437	14,957	22,696	52	8	45	48	212	18	5	7	0	0	0	4	1	0	1
114	Yokohl Valley/ Oat Canyon - Sierra Nevada	727	157	3,596	440	3,439	74	28	204,110	826	270	375	261, 293	5,248	5,807	12	3	10	88	254	14	32	23	0	55	2	0	0	0	2
115	Indio Hills - San Jacinto Mountains	222	54	492	84	438	22	35	28,944	117	73	74	65	13,927	16,458	30	17	13	70	203	20	17	22	20	9	2	34	1	0	2

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
96	17	0.1	95	0.4	1	CENTRAL COAST	1	Santa Cruz Mountains	3	BIG BASIN, SAN MATEO, SANTA CLARA	0	3	San Mateo, Santa Clara, Santa Cruz	68	19	1	0	0	11	0	0	0
97	65	0.1	77	0.2	1	CENTRAL COAST	3	Watsonville Plain-Salinas Valley, North Costal Santa Lucia Range, Interior Santa Lucia Range	3	CARMEL RIVER, SALINAS, SANTA LUCIA	0	1	Monterey	15	69	5	1	0	10	0	0	0
98	56	0.2	68	0.2	1	CENTRAL COAST	3	Santa Maria Valley, Santa Ynez Valleys and Hills, Santa Ynez-Sulphur Mountains	4	SAN ANTONIO, SANTA MARIA, SANTA YNEZ, SOUTH COAST	0	1	Santa Barbara	1	71	4	4	0	13	5	1	0
99	67	0.1	143	0.3	1	SOUTH COAST	8	Santa Ynez-Sulphur Mountains, Oxnard Plain-Santa Paula Valley, Simi Valley-Santa Susana Mountains, Santa Monica Mountains, Los Angeles Plain, San Rafael-Topatopa Mountains, Northern Transverse Ranges, Sierra Pelona-Mint Canyon	4	CALLEGUAS, LOS ANGELES RIVER, SANTA CLARA - CALLEGUAS, SANTA MONICA BAY	0	2	Ventura, Los Angeles	0	66	13	1	0	15	2	1	1
100	0	0.0	40	0.4	1	SOUTH COAST	3	Fontana Plain-Calimesa Terraces, Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	2	SAN JACINTO VALLEY, SANTA ANA RIVER	0	2	San Bernardino, Riverside	3	58	22	1	0	15	0	1	0
101	24	0.3	6	0.1	1	SOUTH COAST	2	San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains	2	SAN JACINTO VALLEY, SANTA MARGARITA	0	1	Riverside	45	35	8	0	2	9	0	0	0
102	21	0.4	0	0.0	2	SONORAN DESERT, SOUTH COAST	3	San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains, Desert Slopes NA No Description	4	ANZA BORREGO, CLARK, SAN JACINTO VALLEY, WHITEWATER	0	1	Riverside	37	26	17	0	0	7	0	0	13
103	0	0.0	16	0.2	1	SOUTH COAST	3	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains	2	SAN JACINTO VALLEY, SANTA MARGARITA	0	1	Riverside	7	71	14	0	0	7	0	0	2
104	8	0.1	26	0.2	1	SOUTH COAST	2	Coastal Hills, Western Granitic Foothills	3	PENASQUITOS, SAN DIEGO, SAN DIEGUITO	0	1	San Diego	1	64	23	0	0	10	1	0	1
105	41	0.1	155	0.4	1	SOUTH COAST	6	Coastal Hills, Santa Ana Mountains, Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains, Western Granitic Foothills, Palomar-Cuyamaca Peak	4	SAN JACINTO VALLEY, SAN JUAN, SAN LUIS REY, SANTA MARGARITA	6	3	Riverside, Orange, San Diego	2	63	8	2	0	15	10	0	1
106	0	0.0	0	0.0	1	SONORAN DESERT	1	East Mesa-Sand Hills	2	IMPERIAL, YUMA	0	1	Imperial	0	1	0	1	0	0	0	0	98
107	0	0.0	19	0.1	1	SONORAN DESERT	3	Chocolate Mountains and Valleys, East Mesa-Sand Hills, Gila Bend Plain Desert Shrubland	4	AMOS-OGILBY, COLORADO, IMPERIAL, YUMA	0	1	Imperial	0	24	0	45	0	0	0	0	31
108	24	0.2	9	0.1	2	SONORAN DESERT, SOUTH COAST	2	Palomar-Cuyamaca Peak, Desert Slopes NA No Description	2	ANZA BORREGO, TIJUANA	0	1	San Diego	4	53	35	1	0	7	0	0	0
109	15	0.1	40	0.3	1	SOUTH COAST	3	Coastal Hills, Western Granitic Foothills, Palomar-Cuyamaca Peak	3	OTAY, SAN DIEGO, SWEETWATER	0	1	San Diego	0	71	5	2	2	19	1	0	0
110	0	0.0	51	0.1	1	NORTH COAST	4	Trinity Mountain-Hayfork, Rattlesnake Creek, Eastern Franciscan, Western Foothills	3	MAD RIVER, SHASTA BALLY, TRINITY RIVER	0	3	Trinity, Shasta, Tehama	76	15	2	0	0	4	0	0	2
111	9	0.0	46	0.1	1	NORTH COAST	9	Northern Franciscan, Western Jurassic, Gasquet Mountain Ultramafics, Lower Salmon Mountains, Forks of Salmon, North Trinity Mountain, Trinity Mountain-Hayfork, Eastern Franciscan	2	KLAMATH RIVER, TRINITY RIVER	0	3	Siskiyou, Humboldt, Trinity	90	3	0	1	1	3	0	0	2
112	67	0.2	25	0.1	1	MODOC PLATEAU	3	Shignletown-Paradise, Lassen-Almanor, Tuscan Flows	4	EASTERN TEHAMA, FEATHER RIVER, PIT RIVER, WHITMORE	0	4	Shasta, Lassen, Tehama, Plumas	86	2	0	6	0	2	0	0	4
113	31	0.1	6	0.0	1	SIERRA NEVADA	4	Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Glaciated Batholith and Volcanic Flows, Batholith and Volcanic Flows	3	MIDDLE SIERRA, STANISLAUS RIVER, UPPER CALAVERAS	0	3	Alpine, Calaveras, Tuolumne	85	1	0	6	1	2	0	0	5
114	95	0.1	78	0.1	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	4	Hardpan Terraces, Lower Batholith, Upper Batholith, Lower Granitic Foothills	5	KAWEAH RIVER, KERN RIVER, KINGS RIVER, SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	2	Fresno, Tulare	24	33	37	4	0	1	0	0	0
115	31	0.3	28	0.2	2	SONORAN DESERT, SOUTH COAST	3	San Jacinto Mountains, Desert Slopes NA No Description, Coachella Valley	2	SAN JACINTO VALLEY, WHITEWATER	9	1	Riverside	0	62	1	10	0	7	0	0	20

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
116	East Mesa Sand Dunes - Chocolate Mountains	41	0	169	30	169	88	29	217,841	882	3	50	2, 12	18,433	19,884	84	4	79	16	174	23	9	15	0	0	2	2	1	0	2
117	Miramar - Canada de San Vicente/Iron Mountain	264	107	606	74	499	5	9	23,531	95	27	33	24	10,330	13,797	54	18	36	46	274	3	18	22	57	7	2	7	4	0	1
118	Burnt Mountain - Black Mountain/Guejito Creek	516	220	982	106	762	27	28	12,221	49	45	46		6,360	9,227	20	17	2	80	260	1	2	3	0	7	1	14	3	1	0
119	Lake Perris - The Badlands East	455	428	658	31	230	30	38	6,395	26	79	82		4,507	7,641	81	14	67	19	267	1	6	10	100	2	1	55	2	0	0
120	Estelle Mountain - Lake Matthews	496	316	837	100	521	21	19	4,428	18	75	81		1,302	2,369	19	7	12	81	269	3	3	8	0	40	3	54	2	0	0
121	Mooney Island - Ishi Wilderness	126	60	751	124	691	27	32	16,358	66	692	695		1,876	3,990	12	7	5	88	235	11	0	19	0	0	0	0	0	19	1
122	Poso Creek - Five Dog Creek	311	230	392	27	162	75	31	13,573	55	215	223		8,588	9,795	1	0	1	99	208	1	0	3	0	0	0	0	0	0	0
123	Ten Section Oil Field - Elk Hills	116	80	421	54	341	33	36	47,652	193	200	210	198	4,801	7,388	20	10	10	80	198	3	11	22	71	0	0	54	1	0	1
124	Kettleman Hills/ Las Alturas - Table Mountain/ Chino Canyon	263	89	1,128	125	1,039	52	40	142,471	577	255	284	263, 273, 277	8,543	12,903	17	16	0	83	197	10	9	14	0	0	0	5	1	0	3
125	Santa Cruz Mountains/ Pescadero Creek - Pigeon Point	108	36	448	92	412	32	35	6,325	26	337	342	401	11,915	14,428	10	9	1	90	247	8	3	8	0	12	1	25	1	1	2
126	Curry Creek - Coon Creek	28	18	39	3	21	45	38	15,002	61	545	555		12,076	13,400	14	10	4	86	222	1	2	6	0	0	0	53	1	50	0
127	Yolo Bypass - Sacramento Bypass	4	0	10	2	10	4	15	11,647	47	515	535		11,403	14,246	68	7	61	32	231	1	0	3	0	89	1	0	0	6	1
128	English Hills - Blue Ridge/ Rocky Ridge	206	32	863	166	831	66	35	34,622	140	532	570		7,494	12,310	37	24	13	63	251	9	3	8	0	0	0	16	1	2	0
129	Mandeville Island - Staten Island	-1	-3	4	1	7	5	16	16,976	69	441	464		5,689	13,661	14	13	0	86	232	1	7	5	0	100	1	0	0	6	0
130	Little Holland Tract/ Yolo Bypass - Yolo Bypass	3	0	10	2	10	14	21	5,082	21	501	515		1,432	3,488	5	4	1	95	231	2	0	1	0	100	1	0	0	11	0
131	Pixley National Wildlife Refuge - Cross Creek	66	63	69	1	6	10	24	14,192	57	265	274		6,984	9,852	1	1	0	99	198	1	0	4	0	6	1	6	1	26	0
132	Ash Slough - Merced National Wildlife Refuge	36	29	42	3	13	17	31	15,131	61	332	338	346	10,072	11,764	6	2	5	94	220	5	2	6	0	4	5	4	1	22	0
133	Fresno River - Lone Willow	45	42	53	1	11	7	17	7,152	29	327	329		6,589	8,014	0	0	0	100	211	1	1	2	0	0	0	0	0	13	0
134	Gravelly Ford Canal - Fresno River	52	46	61	3	15	39	42	19,671	80	320	327	324	6,907	7,722	4	4	0	96	209	2	5	3	0	0	0	0	0	50	0
135	Lone Willow - Ash Slough	41	37	45	2	8	20	31	8,635	35	329	332		2,563	3,148	0	0	0	100	213	4	2	3	0	0	0	0	0	23	0
136	Bald Mountain Range - Reconnaissance Peak	1,597	1,489	2,448	206	959	18	31	33,905	137	613	629		4,634	15,074	53	40	13	47	236	11	6	0	0	0	0	0	0	12	2
137	Allensworth - Pixley National Wildlife Refuge	74	61	82	4	21	3	11	4,849	20	241	249		1,200	2,149	2	2	0	98	200	4	3	10	0	16	1	17	1	19	0
138	Five Dog Creek - Gordon Gulch/ Sand Canyon	294	222	384	27	162	75	31	12,524	51	223	230		2,236	4,498	0	0	0	100	215	11	0	0	0	0	0	0	0	0	0
139	Mountain House - Brushy Peak	193	43	390	79	347	46	35	7,546	31	403	419		2,341	3,488	0	0	0	100	233	8	6	9	0	0	1	100	1	1	1

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
116	66	0.1	7	0.0	1	SONORAN DESERT	3	Chocolate Mountains and Valleys, Imperial Valley, East Mesa-Sand Hills	4	AMOS-OGILBY, CHUCKWALLA, COLORADO, IMPERIAL	0	2	Riverside, Imperial	0	59	0	8	0	1	1	1	30
117	5	0.1	11	0.1	1	SOUTH COAST	3	Coastal Hills, Coastal Terraces, Western Granitic Foothills	2	PENASQUITOS, SAN DIEGO	0	1	San Diego	0	85	4	1	2	8	0	0	0
118	0	0.0	19	0.4	1	SOUTH COAST	2	Western Granitic Foothills, Palomar-Cuyamaca Peak	3	CARLSBAD, SAN DIEGUITO, SAN LUIS REY	0	1	San Diego	0	79	8	3	1	6	2	1	0
119	0	0.0	10	0.4	1	SOUTH COAST	2	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	1	SAN JACINTO VALLEY	0	1	Riverside	0	30	41	0	4	14	7	3	0
120	0	0.0	9	0.5	1	SOUTH COAST	1	Perris Valley and Hills	1	SANTA ANA RIVER	0	1	Riverside	2	49	29	0	3	15	1	0	1
121	10	0.2	19	0.3	2	GREAT CENTRAL VALLEY, MODOC PLATEAU	2	North Valley Alluvium, Tuscan Flows	2	EASTERN TEHAMA, TEHAMA	0	1	Tehama	0	20	18	5	3	8	28	17	0
122	0	0.0	10	0.2	1	GREAT CENTRAL VALLEY	1	Hardpan Terraces	1	SOUTH VALLEY FLOOR	0	1	Kern	0	0	94	0	0	6	0	0	0
123	30	0.2	35	0.2	1	GREAT CENTRAL VALLEY	3	Antelope Plain, South Valley Alluvium and Basins, Elk Hills and South Valley Terraces	1	SOUTH VALLEY FLOOR	0	1	Kern	0	8	62	7	1	11	8	3	1
124	66	0.1	21	0.0	2	CENTRAL COAST, GREAT CENTRAL VALLEY	5	Panoche and Cantua Fans and Basins, Antelope Plain, Diablo Range, Eastern Hills, Kettleman Hills and Valleys	5	COAST RANGE, ESTRELLA RIVER, SALINAS, SOUTH VALLEY FLOOR, SUNFLOWER VALLEY	15	3	Fresno, Monterey, Kings	1	2	72	0	0	10	12	1	1
125	12	0.5	14	0.6	1	CENTRAL COAST	3	Santa Clara Valley, Leeward Hills, Western Diablo Range	2	PAJARO RIVER, SANTA CLARA	0	2	Santa Clara, San Benito	1	22	27	4	0	11	34	0	1
126	0	0.0	21	0.3	1	GREAT CENTRAL VALLEY	1	Hardpan Terraces	1	VALLEY-AMERICAN	0	1	Placer	0	1	52	4	0	5	26	11	0
127	6	0.1	9	0.2	1	GREAT CENTRAL VALLEY	2	Yolo Alluvial Fans, Yolo-American Basins	2	SACRAMENTO DELTA, VALLEY PUTAH-CACHE	0	1	Yolo	0	1	13	27	6	4	47	2	0
128	0	0.0	29	0.2	2	GREAT CENTRAL VALLEY, NORTH COAST	4	Suisun Hills and Valleys, Yolo Alluvial Fans, Sodic Claypan Terraces, Western Foothills	3	PUTAH CREEK, UPPER ELMIRA, VALLEY PUTAH-CACHE	0	3	Yolo, Napa, Solano	0	61	27	2	1	4	6	0	0
129	0	0.0	5	0.1	1	GREAT CENTRAL VALLEY	1	Delta	2	SACRAMENTO DELTA, SAN JOAQUIN DELTA	0	3	Sacramento, San Joaquin, Contra Costa	0	0	1	17	20	2	59	0	0
130	0	0.0	0	0.0	1	GREAT CENTRAL VALLEY	1	Yolo-American Basins	1	SACRAMENTO DELTA	0	1	Yolo	0	2	12	17	11	1	57	2	0
131	0	0.0	16	0.3	1	GREAT CENTRAL VALLEY	2	Granitic Alluvial Fans and Terraces, Tulare Basin	1	SOUTH VALLEY FLOOR	0	2	Tulare, Kings	0	0	19	1	2	5	51	22	0
132	0	0.0	13	0.2	1	GREAT CENTRAL VALLEY	3	Manteca-Merced Alluvium, San Joaquin Basin, Granitic Alluvial Fans and Terraces	2	DELTA-MENDOTA CANAL, SAN JOAQUIN VALLEY FLOOR	0	2	Madera, Merced	0	0	14	4	0	4	44	34	0
133	0	0.0	2	0.1	1	GREAT CENTRAL VALLEY	2	Hardpan Terraces, Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	8	4	0	2	63	23	0
134	0	0.0	17	0.2	1	GREAT CENTRAL VALLEY	2	Hardpan Terraces, Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	42	2	0	6	21	30	0
135	0	0.0	3	0.1	1	GREAT CENTRAL VALLEY	2	San Joaquin Basin, Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	19	2	0	3	32	44	0
136	20	0.1	9	0.1	2	SIERRA NEVADA, MODOC PLATEAU	3	Frenchman, Sierra Valley, Tahoe-Truckee	2	FEATHER RIVER, SUSANVILLE	0	3	Lassen, Plumas, Sierra	28	56	0	3	0	2	1	10	0
137	0	0.0	5	0.2	1	GREAT CENTRAL VALLEY	3	Granitic Alluvial Fans and Terraces, Tulare Basin, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	1	Tulare	0	0	20	0	0	4	43	33	0
138	0	0.0	0	0.0	1	GREAT CENTRAL VALLEY	2	Hardpan Terraces, Southern Granitic Foothills	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Kern	0	0	98	0	0	1	0	0	0
139	14	0.5	9	0.3	1	GREAT CENTRAL VALLEY	2	Westside Alluvial Fans and Terraces, Eastern Hills	3	NORTH DIABLO RANGE, SAN JOAQUIN DELTA, SOUTH BAY	0	1	Alameda	0	1	86	0	0	12	0	0	0

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
140	Montezuma Hills - Hopkins Ravine	57	4	88	14	84	44	31	8,577	35	459	467		5,326	7,218	2	2	0	98	226	2	2	3	0	0	0	4	1	1	0
141	Santa Cruz Mountains/ Pescadero Creek - Santa Cruz Mountains	357	80	779	139	699	47	25	23,306	94	337	361	345, 349	3,612	4,974	9	9	0	91	272	6	9	3	0	0	0	0	1	0	0
142	Santa Cruz Mountains - Diablo Range	305	49	1,139	232	1,090	21	29	96,658	391	361	401	342, 345, 349	4,807	11,729	15	13	2	85	247	10	28	18	0	25	3	15	1	1	2
143	San Luis Island - Bear Creek	27	21	32	2	11	59	37	12,664	51	344	346		3,106	6,087	93	62	31	7	223	1	8	16	0	50	6	50	1	66	0
144	San Luis Canal - Ortigalita Ridge/ San Luis Reservoir	179	30	856	127	826	45	40	23,956	97	333	340		3,578	4,448	13	11	2	87	215	9	7	19	0	1	1	47	2	16	1
145	San Geronimo - Los Padres National Forest	381	0	1,341	233	1,341	65	37	145,571	589	242	314	247, 257, 262, 272	2,309	6,921	47	29	18	53	279	22	54	22	11	0	2	31	1	1	1
146	Stone Lake - Yolo Bypass	2	0	8	2	8	16	30	16,465	67	490	515	502, 507	13,286	18,617	50	32	18	50	231	1	4	17	0	79	1	0	0	30	1
147	Blue Ridge/ Rocky Ridge - Capay Hills	157	64	926	134	862	19	31	19,557	79	570	575		1,000	4,873	6	5	1	94	232	8	0	3	0	0	0	10	1	0	0
148	Dunnigan Hills/ Smith Creek - Dunnigan Hills	51	14	98	18	84	66	38	13,830	56	551	560		2,319	5,743	0	0	0	100	220	8	0	3	0	0	0	0	0	5	1
149	Sacramento National Wildlife Refuge - Clark Valley	40	19	276	32	257	37	42	17,231	70	616	644	621	5,053	5,991	46	46	0	54	219	5	12	4	0	0	0	11	1	35	1
150	Black Oak Mountain - Red Mountain	632	249	1,141	183	892	61	29	14,579	59	686	697		7,355	8,440	54	5	48	46	254	6	7	3	0	58	2	0	0	0	1
151	Sinkyone - King Range	486	4	948	164	944	60	29	15,293	62	709	733		3,276	3,770	63	11	53	37	272	21	6	2	0	63	2	0	0	0	0
152	Marble Mountains - Siskiyou Mountains	1,031	373	1,961	369	1,588	56	31	43,279	175	843	847		2,657	3,891	88	1	86	12	235	4	3	8	0	37	2	0	0	0	1
153	Little Cottonwood Pk - Wadsworth Flat	1,009	626	2,000	325	1,374	54	34	14,321	58	842	844		2,921	8,728	23	0	23	77	251	14	2	4	0	0	0	0	0	1	1
154	Butte Valley - Wadsworth Flat	1,189	662	1,886	277	1,224	66	31	75,118	304	834	844	830, 838, 839, 841	22,163	23,629	22	0	22	78	265	11	3	12	0	4	1	0	0	1	1
155	Double Head Mountain/ Timbered Ridge - Lava Beds Wilderness	1,350	1,231	1,579	66	348	76	31	126,203	511	814	817	802, 804, 810, 824	1,300	1,652	92	34	58	8	255	9	11	8	0	0	0	0	0	2	1
156	Timber Mountain - Double Head Mountain/ Timbered Ridge	1,474	1,277	1,613	58	336	54	26	75,788	307	802	814		1,574	22,215	100	0	100	0	256	6	5	3	0	0	0	0	0	4	1
157	Pilot Butte - Little Hot Spring Valley	1,372	1,007	1,928	210	921	52	33	33,036	134	768	774	765, 773, 776	18,736	19,883	26	4	22	74	252	6	8	8	0	1	1	1	1	6	0
158	Bald Hills - Beaver Creek Rim/ Indian Mountain	1,816	1,365	2,179	111	814	55	23	47,332	192	716	742	721	2,530	16,025	39	1	38	61	266	6	8	12	0	0	0	0	0	4	1
159	Thousand Lakes - Cinder Butte	1,333	987	1,876	227	889	50	28	17,493	71	722	736		3,860	4,846	29	0	28	71	233	4	3	3	0	1	1	1	1	1	1
160	Lassen Volcanic Wilderness - Thousand Lakes	1,934	1,563	3,122	270	1,559	68	28	37,983	154	710	722	707	7,300	7,411	95	48	47	5	217	8	13	15	0	0	0	0	0	1	2
161	Adams Peak - Fort Sage Mountains	1,406	1,298	2,260	129	962	59	35	17,915	73	624	647	633	5,571	6,574	35	0	35	65	262	17	6	1	0	0	0	0	0	10	1
162	Adams Peak - Reconnaissance Peak	1,771	1,485	2,363	135	878	54	30	20,052	81	624	629		5,295	7,198	80	4	76	20	255	10	8	1	0	0	0	0	0	2	0
163	Reconnaissance Peak - Diamond Mountains	1,968	1,640	2,522	157	882	63	22	46,434	188	629	652		5,954	7,571	93	0	93	7	234	13	10	2	0	0	0	0	0	2	0

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
140	0	0.0	11	0.3	1	GREAT CENTRAL VALLEY	2	Sodic Claypan Terraces, Delta	2	SUISUN, VALLEY PUTAH-CACHE	0	1	Solano	0	2	48	1	0	3	1	45	0
141	0	0.0	44	0.5	1	CENTRAL COAST	4	Santa Clara Valley, Santa Cruz Mountains, Leeward Hills, Watsonville Plain-Salinas Valley	2	BIG BASIN, PAJARO RIVER	0	2	Santa Clara, Santa Cruz	32	56	5	0	0	6	1	0	0
142	41	0.1	171	0.4	1	CENTRAL COAST	6	Santa Clara Valley, Santa Cruz Mountains, Leeward Hills, Fremont-Livermore Hills and Valleys, Western Diablo Range, Diablo Range	5	BIG BASIN, MIDDLE WEST SIDE, PAJARO RIVER, SANTA CLARA, SOUTH BAY	0	3	Stanislaus, Santa Clara, Santa Cruz	13	34	22	2	1	23	4	1	0
143	0	0.0	0	0.0	1	GREAT CENTRAL VALLEY	2	Manteca-Merced Alluvium, San Joaquin Basin	2	DELTA-MENDOTA CANAL, SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	0	15	49	0	5	13	16	0
144	19	0.2	4	0.0	2	CENTRAL COAST, GREAT CENTRAL VALLEY	4	Westside Alluvial Fans and Terraces, San Joaquin Basin, Diablo Range, Eastern Hills	2	DELTA-MENDOTA CANAL, MIDDLE WEST SIDE	0	1	Merced	0	2	57	9	1	7	22	3	0
145	62	0.1	47	0.1	1	CENTRAL COAST	3	North Costal Santa Lucia Range, South Costal Santa Lucia Range, Interior Santa Lucia Range	3	ESTERO BAY, SALINAS, SANTA LUCIA	0	2	Monterey, San Luis Obispo	20	58	13	2	1	5	0	0	1
146	25	0.4	30	0.5	1	GREAT CENTRAL VALLEY	3	Hardpan Terraces, Yolo-American Basins, Sodic Claypan Terraces	2	SACRAMENTO DELTA, VALLEY-AMERICAN	0	2	Yolo, Sacramento	0	1	29	15	6	9	35	6	0
147	0	0.0	21	0.3	2	GREAT CENTRAL VALLEY, NORTH COAST	3	Yolo Alluvial Fans, Western Foothills, Dunnigan Hills	4	COLUSA BASIN, PUTAH CREEK, UPPER ELMIRA, VALLEY PUTAH-CACHE	0	2	Yolo, Napa	1	18	44	2	0	8	24	2	0
148	23	0.4	10	0.2	1	GREAT CENTRAL VALLEY	2	Yolo Alluvial Fans, Dunnigan Hills	2	COLUSA BASIN, VALLEY PUTAH-CACHE	0	1	Yolo	0	1	73	0	0	6	19	1	0
149	18	0.3	25	0.4	2	GREAT CENTRAL VALLEY, NORTH COAST	4	North Valley Alluvium, Colusa Basin, Western Foothills, Dunnigan Hills	2	COLUSA BASIN, CORTINA	0	2	Glenn, Colusa	0	2	26	19	1	6	44	1	0
150	11	0.2	4	0.1	1	NORTH COAST	2	Coastal Franciscan, Central Franciscan	1	EEL RIVER	32	1	Mendocino	85	7	0	0	0	4	0	0	3
151	0	0.0	37	0.6	1	NORTH COAST	1	Coastal Franciscan	3	CAPE MENDOCINO, EEL RIVER, MENDOCINO COAST	0	2	Humboldt, Mendocino	88	4	0	0	0	7	0	0	0
152	16	0.1	2	0.0	1	NORTH COAST	6	Western Jurassic, Siskiyou Mountains, Scott Bar Mountain, Lower Salmon Mountains, Upper Salmon Mountains, Windy Peak	2	KLAMATH RIVER, ROGUE RIVER	0	1	Siskiyou	86	5	1	1	0	6	0	0	2
153	18	0.3	8	0.1	2	MODOC PLATEAU, NORTH COAST	2	Scott Bar Mountain, Old Cascades	1	KLAMATH RIVER	0	1	Siskiyou	64	23	1	3	0	5	0	3	1
154	5	0.0	45	0.2	1	MODOC PLATEAU	3	Old Cascades, High Cascade, Medicine Lake Lava Flows	1	KLAMATH RIVER	0	1	Siskiyou	58	27	3	5	1	1	2	1	1
155	30	0.1	37	0.1	1	MODOC PLATEAU	4	Medicine Lake Lava Flows, Lower Klamath-Tule Lake Basins, Devil's Garden, Mowitz Buttes	2	KLAMATH RIVER, PIT RIVER	0	2	Siskiyou, Modoc	24	72	0	1	0	1	1	1	0
156	14	0.1	1	0.0	1	MODOC PLATEAU	3	Medicine Lake Lava Flows, Devil's Garden, Mowitz Buttes	2	KLAMATH RIVER, PIT RIVER	0	1	Modoc	74	24	1	1	0	0	0	0	0
157	0	0.0	23	0.2	1	MODOC PLATEAU	4	Medicine Lake Lava Flows, Hat Creek Rim, Mowitz Buttes, Bald Mountain-Dixie Valley	1	PIT RIVER	0	4	Siskiyou, Modoc, Shasta	60	17	0	6	0	1	8	5	3
158	4	0.0	0	0.0	1	MODOC PLATEAU	3	Blacks Mountain-Susanville Peak, Bald Mountain-Dixie Valley, Eagle Lake-Observation Peak	3	MADELINE PLAINS, PIT RIVER, SUSANVILLE	1	1	Lassen	85	8	0	5	1	0	0	0	0
159	11	0.2	0	0.0	1	MODOC PLATEAU	2	Hat Creek Rim, Lassen-Almanor	1	PIT RIVER	0	1	Shasta	75	9	0	5	0	2	6	1	3
160	38	0.3	7	0.1	1	MODOC PLATEAU	2	Hat Creek Rim, Lassen-Almanor	3	FEATHER RIVER, PIT RIVER, WHITMORE	0	2	Shasta, Plumas	80	4	0	4	0	2	0	0	10
161	10	0.1	9	0.1	2	SIERRA NEVADA, MODOC PLATEAU	4	Diamond Mountains-Crystal Peak, Frenchman, Fort Sage Mountains-Lemmon Valley, Honey Lake Basin	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	24	60	0	7	0	2	2	4	0
162	0	0.0	0	0.0	2	SIERRA NEVADA, MODOC PLATEAU	4	Diamond Mountains-Crystal Peak, Frenchman, Sierra Valley, Fort Sage Mountains-Lemmon Valley	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	74	21	0	3	0	1	0	0	0
163	0	0.0	0	0.0	1	SIERRA NEVADA	2	Diamond Mountains-Crystal Peak, Frenchman	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	91	4	0	4	0	0	0	0	1

Characteristics of Essential Connectivity Areas

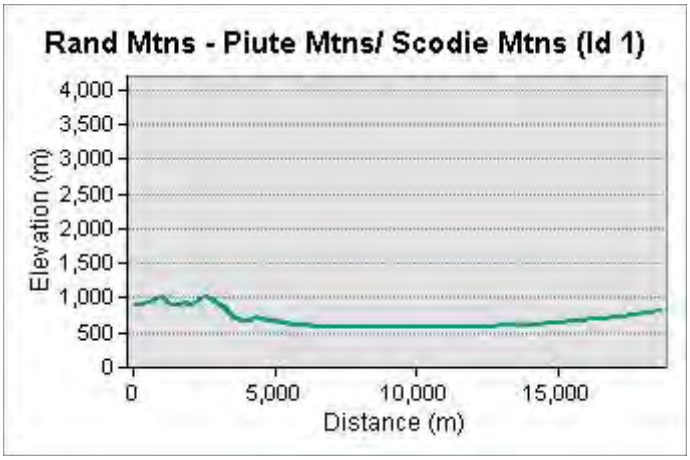
Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
164	Mt Killmore - Grizzly Mountain	1,658	1,131	2,348	280	1,217	57	26	79,243	321	637	654	617, 631	3,890	14,218	63	5	58	37	223	11	12	11	0	0	0	0	0	1	1
165	Sawtooth Ridge - Lafayette Ridge/ Black Buttes	1,920	803	2,435	177	1,632	53	27	23,730	96	572	595		1,217	3,123	49	3	46	51	182	12	6	7	0	0	0	0	0	1	1
166	Middle Fork Cosumnes River - Big Mountain Ridge	734	371	1,127	144	756	46	26	21,912	89	511	512	493	1,640	7,946	5	0	5	95	249	23	2	1	0	0	0	100	1	2	0
167	Quartz Mountain - Logtown Ridge	395	125	573	70	448	43	33	8,619	35	485	516	487, 492, 511	942	4,926	1	0	0	99	253	6	0	2	0	0	0	91	1	1	1
168	Bear Mountains - Duck Creek	137	39	626	87	587	53	28	48,963	198	435	442	420, 425, 427	8,736	10,596	4	3	2	96	239	12	3	7	0	8	1	0	1	5	0
169	Calaveras Big Trees - Pine Ridge	1,211	700	1,594	131	894	33	35	18,170	74	437	454		2,944	3,648	32	4	29	68	228	3	1	1	0	0	0	41	1	0	1
170	Coyote Ridge - Owens Mountain	197	128	478	62	350	59	32	30,234	122	308	313		2,302	3,357	0	0	0	100	252	9	3	8	0	29	1	40	1	26	1
171	Coyote Ridge - Sierra Nevada	1,062	128	2,862	649	2,734	77	29	330,688	1,338	308	375	293, 303, 309	10,375	14,583	54	23	31	46	241	26	35	32	0	0	1	0	1	0	2
172	Tennessee Ridge - Frazier Valley/ Rocky Hill	237	152	498	66	346	45	40	12,603	51	252	261	270	2,933	6,261	27	1	26	73	255	6	5	4	0	17	2	0	0	1	0
173	Bluestone Ridge - Sand Ridge	136	59	824	58	765	51	44	58,942	239	250	251	248	19,576	21,473	1	0	1	99	200	8	6	12	0	0	0	0	0	2	2
174	Sulphur Mountain - Pine Mountain/Sespe Condor	528	272	1,136	255	864	31	23	18,465	75	141	160		3,311	10,320	1	0	1	99	262	6	2	8	0	15	4	0	2	0	0
175	Chocolate Mountains South - Chocolate Mountains	207	54	732	91	678	87	27	207,212	839	18	50	15, 26	1,887	2,073	93	1	92	7	200	37	12	32	2	27	2	1	1	0	1
176	San Jacinto Mountains - San Bernardino Mountains	810	133	2,759	675	2,626	43	32	24,512	99	74	101	86	1,204	1,840	31	3	27	69	274	20	36	38	71	8	5	7	3	0	3
177	Vail Lake - Lake Skinner	549	384	835	84	451	23	23	9,170	37	58	64		4,130	4,532	2	0	2	98	266	2	9	14	100	40	2	1	3	0	0
178	Vail Lake - Cahuilla Moutain/Rouse Ridge	806	410	1,659	226	1,249	47	29	19,950	81	58	66		100	8,866	10	1	10	90	262	8	10	26	91	54	4	2	4	1	0
179	Yuha Basin - Anza-Borrego Desert	420	-8	1,414	333	1,422	87	29	190,851	772	9	34	4, 8, 31	3,904	6,573	91	63	28	9	207	22	28	19	0	63	2	0	0	0	1
180	McKittrick Valley - Pixley National Wildlife Refuge	95	67	251	29	184	14	29	25,736	104	217	238	246	16,002	18,944	4	4	0	96	196	4	8	15	0	0	0	17	1	2	3

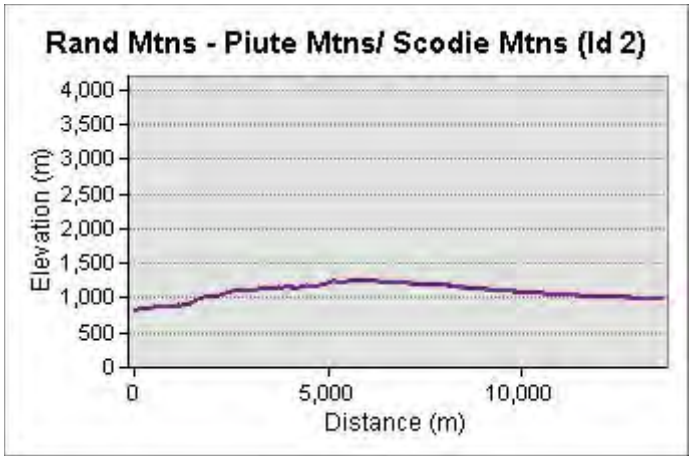
	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
164	22	0.1	26	0.1	1	SIERRA NEVADA	6	Fredonyer Butte-Grizzly Peak, Frenchman, Greenville-Graeagle, Granitic and Metamorphic Foothills, Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows	2	FEATHER RIVER, YUBA RIVER	0	2	Plumas, Sierra	91	2	0	5	0	1	0	0	0
165	26	0.3	3	0.0	1	SIERRA NEVADA	2	Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows	2	AMERICAN RIVER, YUBA RIVER	0	2	Nevada, Placer	84	5	0	6	2	3	0	0	0
166	0	0.0	44	0.5	1	SIERRA NEVADA	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	2	El Dorado, Amador	36	53	0	7	0	3	1	0	0
167	8	0.2	14	0.4	1	SIERRA NEVADA	1	Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	2	El Dorado, Amador	1	80	0	6	0	5	2	5	0
168	0	0.0	67	0.3	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	3	Hardpan Terraces, Camanche Terraces, Lower Foothills Metamorphic Belt	3	GOPHER RIDGE, NORTH VALLEY FLOOR, UPPER CALAVERAS	0	3	Calaveras, San Joaquin, Stanislaus	0	18	66	5	1	6	3	1	0
169	13	0.2	9	0.1	1	SIERRA NEVADA	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	3	MIDDLE SIERRA, STANISLAUS RIVER, UPPER CALAVERAS	0	2	Calaveras, Tuolumne	77	3	0	5	0	10	0	0	3
170	1	0.0	28	0.2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Hardpan Terraces, Lower Granitic Foothills	3	KINGS RIVER, SAN JOAQUIN RIVER, SOUTH VALLEY FLOOR	0	1	Fresno	0	25	62	4	1	3	2	2	0
171	102	0.1	59	0.0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	5	Hardpan Terraces, Granitic Alluvial Fans and Terraces, Lower Batholith, Upper Batholith, Lower Granitic Foothills	3	KAWEAH RIVER, KINGS RIVER, SOUTH VALLEY FLOOR	0	2	Fresno, Tulare	43	35	12	5	2	1	1	0	1
172	0	0.0	13	0.3	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	3	Hardpan Terraces, Granitic Alluvial Fans and Terraces, Lower Granitic Foothills	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Tulare	0	17	62	8	2	5	6	0	0
173	25	0.1	33	0.1	2	CENTRAL COAST, GREAT CENTRAL VALLEY	5	Tulare Basin, Antelope Plain, South Valley Alluvium and Basins, Eastern Hills, Kettleman Hills and Valleys	3	SOUTH VALLEY FLOOR, SUNFLOWER VALLEY, TEMBLOR	0	2	Kings, Kern	0	1	50	0	0	8	32	8	1
174	0	0.0	9	0.1	1	SOUTH COAST	3	Santa Ynez-Sulphur Mountains, San Rafael-Topatopa Mountains, Northern Transverse Ranges	2	SANTA CLARA - CALLEGUAS, VENTURA RIVER	0	1	Ventura	7	79	6	0	0	6	0	0	0
175	56	0.1	15	0.0	1	SONORAN DESERT	5	Chuckwalla Valley, Palo Verde Valley and Mesa, Chocolate Mountains and Valleys, East Mesa-Sand Hills, Gila Bend Plain Desert Shrubland	5	AMOS-OGILBY, CHUCKWALLA, COLORADO, IMPERIAL, YUMA	9	2	Riverside, Imperial	0	32	0	45	0	1	0	0	22
176	49	0.5	7	0.1	3	SONORAN DESERT, SOUTH COAST, MOJAVE DESERT	8	San Gorgonio Mountains, Upper San Gorgonio Mountains, Little San Bernardino-Bighorn Mountains, Fontana Plain-Calimesa Terraces, San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains, Desert Slopes NA No Description, Coachella Valley	4	EMERSON, SAN JACINTO VALLEY, SANTA ANA RIVER, WHITEWATER	1	2	San Bernardino, Riverside	17	30	31	1	0	11	0	0	11
177	0	0.0	19	0.5	1	SOUTH COAST	2	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	1	SANTA MARGARITA	0	1	Riverside	1	52	25	2	0	15	2	3	1
178	0	0.0	10	0.1	1	SOUTH COAST	3	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains	2	SAN JACINTO VALLEY, SANTA MARGARITA	0	1	Riverside	12	45	29	1	1	6	0	1	5
179	97	0.1	86	0.1	2	SONORAN DESERT, SOUTH COAST	4	Palomar-Cuyamaca Peak, Desert Slopes NA No Description, Borrego Valley-West Mesa, Imperial Valley	3	ANZA BORREGO, DAVIES, IMPERIAL	15	2	Imperial, San Diego	2	56	6	5	0	3	0	0	28
180	31	0.3	21	0.2	1	SOUTH COAST	3	Antelope Plain, South Valley Alluvium and Basins, Elk Hills and South Valley Terraces	1	SOUTH VALLEY FLOOR	3	1	Kern	0	4	5	0	0	10	65	14	2

Characteristics of Essential Connectivity Areas

Identifier		Landform					ECI		Area		Essential Connectivity Area					Protection Status				Species Diversity					Listed Species					
ID	ECA_Name	elev_mean	elev_min	elev_max	elev_std	elev_range	mn_integ	std_integ	AREA_ac	AREA_km	pointA	pointB	NLB_In	min_length	lcp_length	pc_protect	pc_gap12e	pc_gap3	pc_privunprp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	mjrd_cross
181	Pine Mountain/Sespe Condor - Lucas Creek	1,101	123	2,689	544	2,566	78	30	580,266	2,348	160	209	164,173,178,179,184,189,191, 193, 194, 196	65,640	92,664	60	52	9	40	246	13	35	44	11	18	5	0	4	0	3
182	Lassen Volcanic Wilderness - Beaver Creek Rim/ Indian Mountain	1,754	1,270	2,472	171	1,202	52	25	156,814	635	710	742	708, 718	30,454	37,722	73	7	66	27	243	13	16	20	0	7	1	7	1	4	2
183	Poso Creek - Sequoia National Forest/ Greenhorn Mountains	510	177	1,315	243	1,138	72	33	47,337	192	215	220	212, 218, 222	5,967	6,504	3	0	3	97	230	18	12	8	13	5	1	0	0	1	0
184	Colusa Basin - Butte Sink	16	12	36	2	24	17	32	18,147	73	601	608	610	11,595	13,699	21	16	6	79	227	5	4	12	23	0	0	0	0	19	1
185	Sugarloaf Mountain/Keller Peak - San Gabriel/Cucamonga	1,295	281	2,860	526	2,579	51	42	289,348	1,171	93	120	94, 95, 97, 98, 99, 102, 103, 119, 132	23,406	34,224	72	26	46	28	270	14	72	53	12	6	9	14	5	0	5
186	Mt Allison - Briones Hills	239	14	805	108	791	9	23	162,438	657	392	446	396, 407, 408, 424, 430, 431, 449, 456	43,525	55,067	38	38	0	62	263	8	27	29	34	42	4	45	1	0	4
187	Rockefeller Redwood Forest - Dairy Ridge/ Pilot Ridge/ South Fork	543	20	1,442	300	1,422	66	29	140,664	569	740	783	755, 762	15,521	18,805	6	5	0	94	238	5	14	19	0	6	2	0	0	0	1
188	La Panza Range - San Geronimo	357	0	1,448	178	1,448	56	37	286,231	1,158	229	242	211, 221, 226, 233, 247, 314	30,438	33,377	18	5	13	82	263	24	58	48	6	2	6	56	4	1	2
189	Elk Hills - Carrizo Plain/ Temblor Range	380	79	1,089	137	1,010	53	37	56,760	230	210	211	217	3,547	4,553	42	12	30	58	205	12	13	18	7	0	0	100	1	0	1
190	San Gabriel Mountains West - San Francisquito	759	419	1,655	189	1,236	43	42	98,705	399	131	147	129, 140, 145	17,951	19,444	58	1	56	42	235	4	12	17	0	3	2	3	4	0	1
191	Sulphur Mountain - Sierra Madre Mountains	561	86	2,190	392	2,104	26	30	70,944	287	141	199	155	5,951	38,577	25	4	22	75	259	12	24	19	0	11	4	72	2	2	1
192	Mt Eddy - Mt Shasta	1,457	1,067	2,470	298	1,403	45	29	29,329	119	799	808		11,763	13,912	50	0	50	50	250	17	18	7	0	13	1	0	0	4	1

	Paved Roads				Ecoregions				Watershed		ACEC	Counties		Land Cover								
ID	mjrd_km	mjrd_dens	secrd_km	secrd_dens	n_ecoreg	Ecoregs	n_subsect	Subsect	HU_num	HU_name	pc_blmacec	n_counties	counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
181	84	0.0	244	0.1	4	SOUTH COAST, MOJAVE DESERT, SIERRA NEVADA, GREAT CENTRAL VALLEY	11	Hardpan Terraces, South Valley Alluvium and Basins, Elk Hills and South Valley Terraces, Tehachapi-Piute Mountains, Southern Granitic Foothills, San Emigdio Mountains, San Rafael-Topatopa Mountains, Northern Transverse Ranges	8	ANTELOPE, GRAPEVINE, KERN RIVER, SANTA CLARA - CALLEGUAS, SANTA MARIA, SOUTH VALLEY FLOOR, SOUTHERN SIERRA, VENTURA RIVER	0	3	Kern, Ventura, Los Angeles	35	28	31	1	0	3	2	0	0
182	28	0.0	19	0.0	1	MODOC PLATEAU	4	Blacks Mountain-Susanville Peak, Hat Creek Rim, Lassen-Almanor, Bald Mountain-Dixie Valley	3	FEATHER RIVER, PIT RIVER, SUSANVILLE	0	3	Shasta, Lassen, Plumas	84	8	0	3	0	1	0	0	3
183	0	0.0	49	0.3	2	SIERRA NEVADA, GREAT CENTRAL VALLEY	2	Hardpan Terraces, Southern Granitic Foothills	3	KERN RIVER, SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Kern	1	38	55	1	0	5	0	0	0
184	2	0.0	30	0.4	1	GREAT CENTRAL VALLEY	3	Butte Sink-Sutter Basin, Colusa Basin, River Alluvium	1	COLUSA BASIN	0	3	Butte, Colusa, Sutter	0	1	11	13	2	6	66	1	0
185	94	0.1	466	0.4	2	SOUTH COAST, MOJAVE DESERT	7	Los Angeles Plain, San Gabriel Mountains, Upper San Gabriel Mountains, San Gorgonio Mountains, Upper San Gorgonio Mountains, Fontana Plain-Calimesa Terraces, High Desert Plains and Hills	5	ANTELOPE, LOS ANGELES RIVER, MOJAVE, SAN GABRIEL RIVER, SANTA ANA RIVER	0	2	San Bernardino, Los Angeles	41	35	6	1	0	13	0	0	2
186	106	0.2	315	0.5	2	CENTRAL COAST, GREAT CENTRAL VALLEY	5	Suisun Hills and Valleys, Bay Flats, East Bay Hills-Mt. Diablo, Fremont-Livermore Hills and Valleys, Western Diablo Range	5	BAY BRIDGES, SAN PABLO, SANTA CLARA, SOUTH BAY, SUISUN	0	3	Contra Costa, Alameda, Santa Clara	5	38	28	1	2	25	0	0	0
187	32	0.1	100	0.2	1	NORTH COAST	2	Central Franciscan, Coastal Franciscan	4	CAPE MENDOCINO, EEL RIVER, MAD RIVER, TRINITY RIVER	1	1	Humboldt	79	6	2	0	0	2	0	0	10
188	108	0.1	169	0.2	2	CENTRAL COAST, GREAT CENTRAL VALLEY	5	South Costal Santa Lucia Range, Interior Santa Lucia Range, Paso Robles Hills and Valleys, Carrizo Plain, Caliente Range-Cuyama Valley	5	CARRIZO PLAIN, ESTERO BAY, ESTRELLA RIVER, SALINAS, SANTA MARIA	1	2	San Luis Obispo, Santa Barbara	10	57	22	2	0	7	1	1	0
189	24	0.1	45	0.2	1	GREAT CENTRAL VALLEY	5	Antelope Plain, South Valley Alluvium and Basins, Elk Hills and South Valley Terraces, Carrizo Plain, Temblor Range	4	CARRIZO PLAIN, FELLOWS, SOUTH VALLEY FLOOR, TEMBLOR	12	2	Kern, San Luis Obispo	1	49	30	0	0	16	0	0	4
190	35	0.1	142	0.4	1	SOUTH COAST	3	Northern Transverse Ranges, Sierra Pelona-Mint Canyon, San Gabriel Mountains	2	LOS ANGELES RIVER, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	14	61	11	1	0	12	0	0	1
191	86	0.3	90	0.3	2	SOUTH COAST, CENTRAL COAST	5	Santa Ynez-Sulphur Mountains, Interior Santa Lucia Range, Caliente Range-Cuyama Valley, San Rafael-Topatopa Mountains, Northern Transverse Ranges	6	BUENAVENTURA, SANTA CLARA - CALLEGUAS, SANTA MARIA, SANTA YNEZ, SOUTH COAST, VENTURA RIVER	0	2	Santa Barbara, Ventura	10	57	7	3	0	17	4	1	0
192	16	0.1	22	0.2	2	MODOC PLATEAU, NORTH COAST	3	Eastern Klamath Mountains, Upper Scott Mountains, High Cascade	4	KLAMATH RIVER, MC CLOUD RIVER, TRINITY RIVER, UPPER SACRAMENTO	0	2	Siskiyou, Trinity	81	5	0	2	0	7	0	0	4


Rand Mtns - Piute Mtns/ Scodie Mtns (Id 1)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)


Rand Mtns - Piute Mtns/ Scodie Mtns (Id 2)
Elevation (m)
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500
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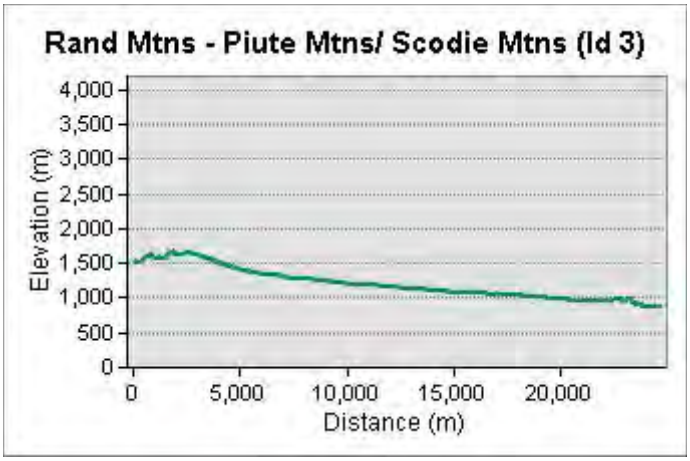
Distance (m)


Rand Mtns - Piute Mtns/ Scodie Mtns (Id 3)
Elevation (m)
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2,000
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1,000
500
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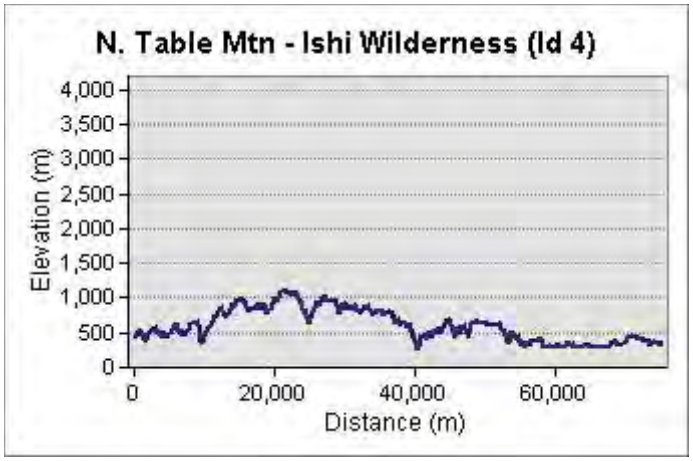
5,000
10,000
15,000
20,000
Distance (m)


N. Table Mtn - Ishi Wilderness (Id 4)
Elevation (m)
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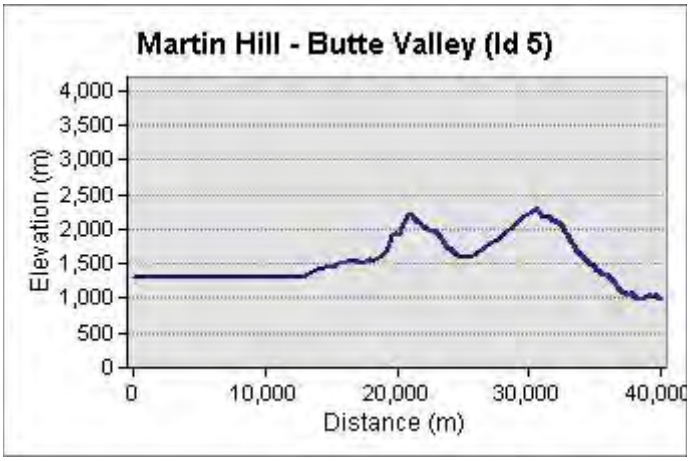
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)


Martin Hill - Butte Valley (Id 5)
Elevation (m)
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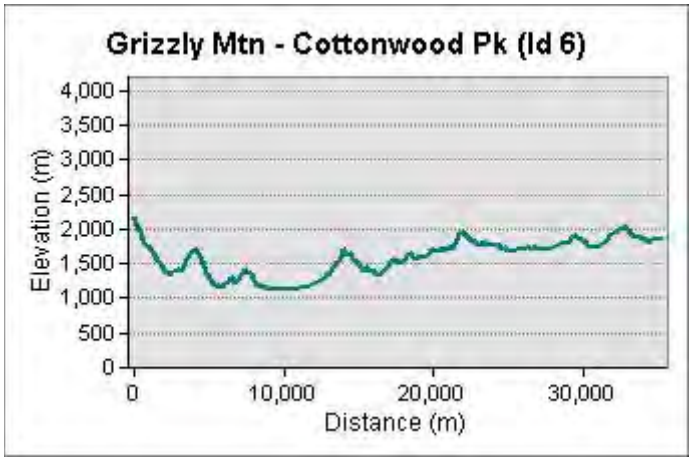
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)


Grizzly Mtn - Cottonwood Pk (Id 6)
Elevation (m)
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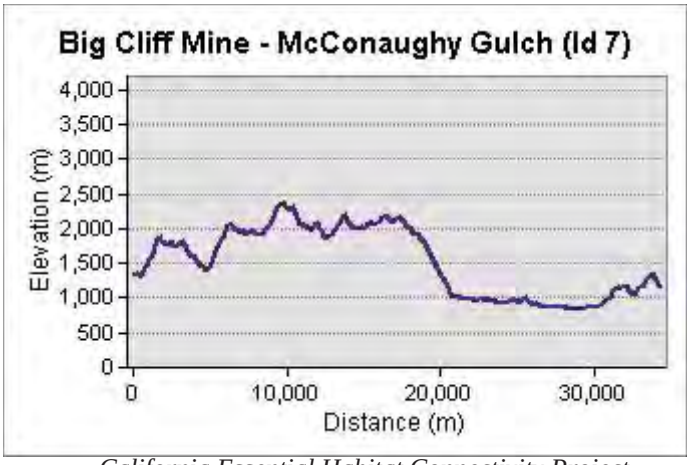
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


Big Cliff Mine - McConaughy Gulch (Id 7)
Elevation (m)
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2,000
1,500
1,000
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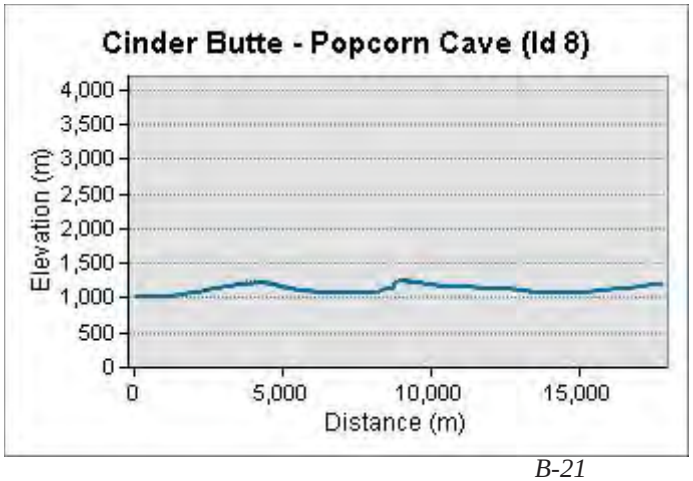
10,000
20,000
30,000
Distance (m)


Cinder Butte - Popcorn Cave (Id 8)
Elevation (m)
4,000
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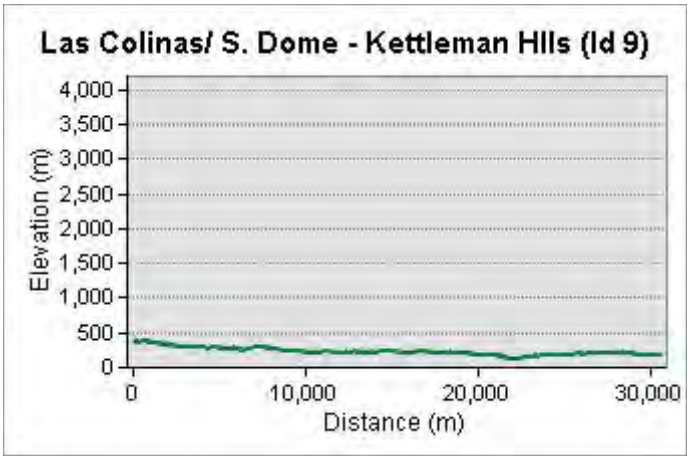
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)


Las Colinas/ S. Dome - Kettleman Hlls (Id 9)
Elevation (m)
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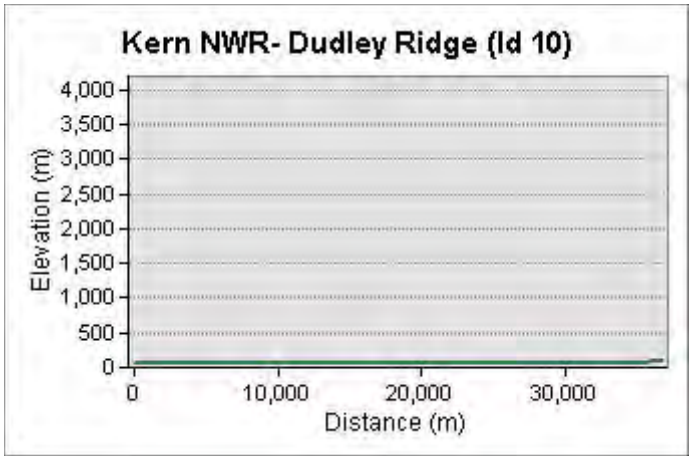
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


Kern NWR- Dudley Ridge (Id 10)
Elevation (m)
4,000
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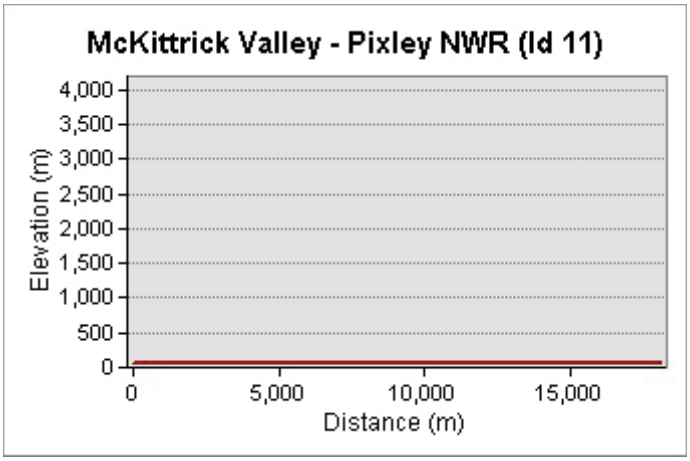
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


McKittrick Valley - Pixley NWR (Id 11)
Elevation (m)
4,000
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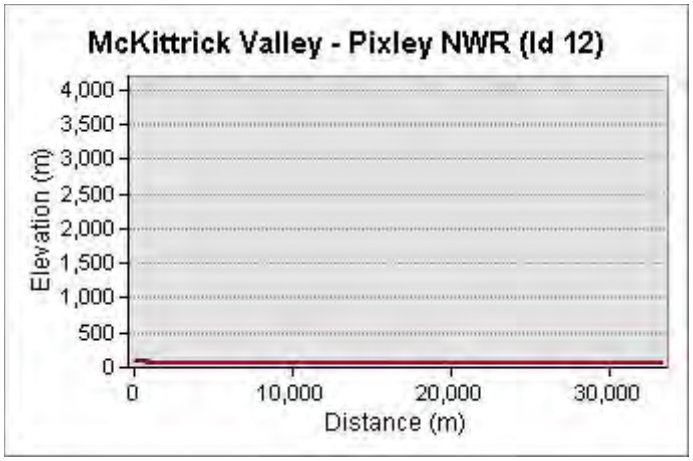
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)


McKittrick Valley - Pixley NWR (Id 12)
Elevation (m)
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3,000
2,500
2,000
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1,000
500
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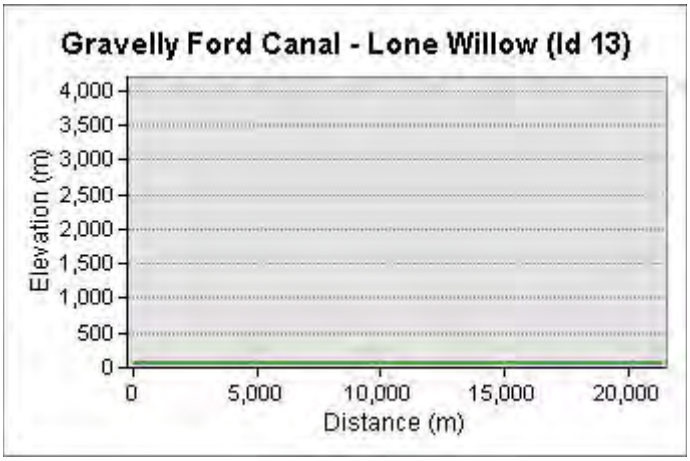
0
10,000
20,000
30,000
Distance (m)


Gravelly Ford Canal - Lone Willow (Id 13)
Elevation (m)
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2,000
1,500
1,000
500
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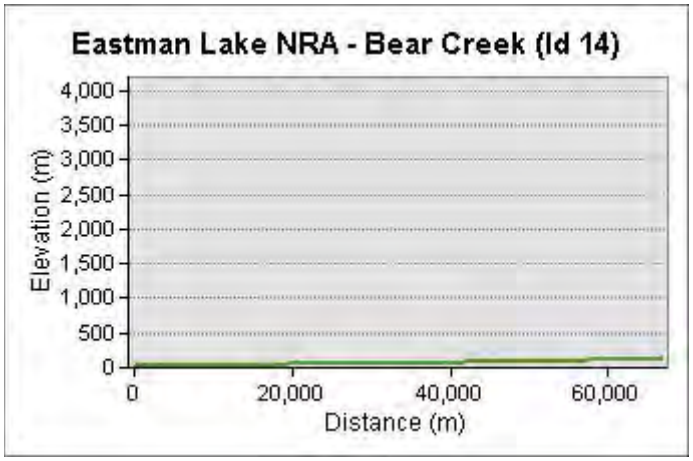
0
5,000
10,000
15,000
20,000
Distance (m)


Eastman Lake NRA - Bear Creek (Id 14)
Elevation (m)
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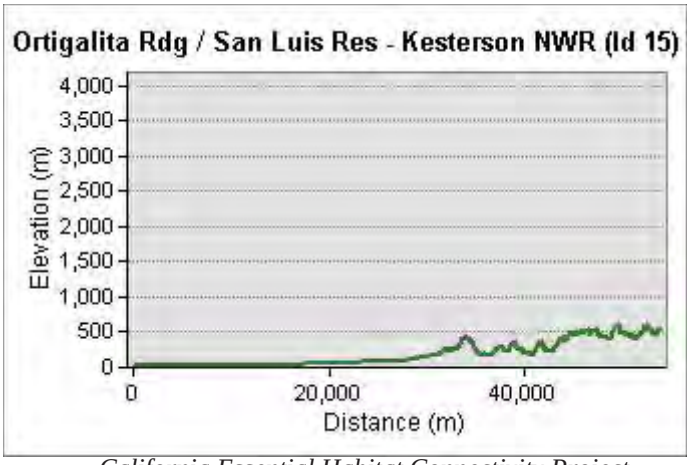
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)


Ortigalita Rdg / San Luis Res - Kesterson NWR (Id 15)
Elevation (m)
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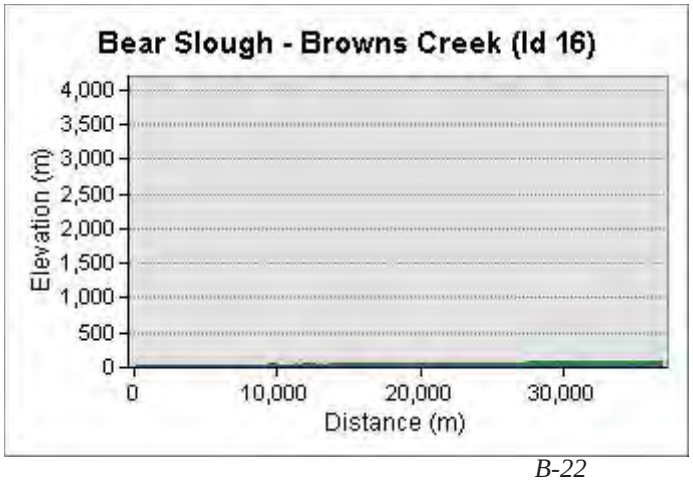
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)


Bear Slough - Browns Creek (Id 16)
Elevation (m)
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500
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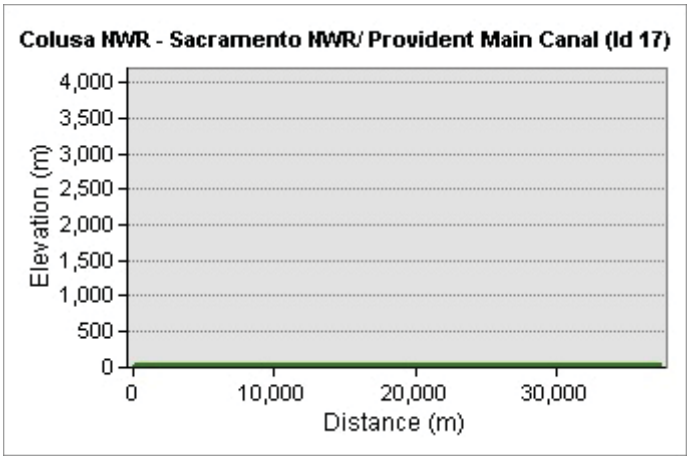
0
10,000
20,000
30,000
Distance (m)


Colusa NWR - Sacramento NWR/ Provident Main Canal (Id 17)
Elevation (m)
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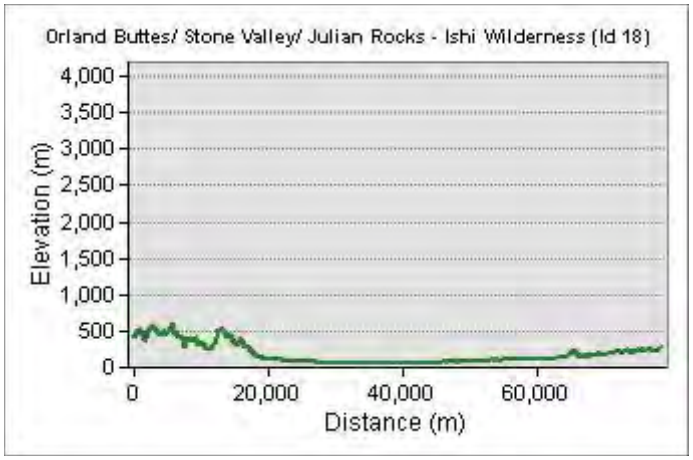
10,000
20,000
30,000
Distance (m)


Orland Buttes/ Stone Valley/ Julian Rocks - Ishi Wilderness (Id 18)
Elevation (m)
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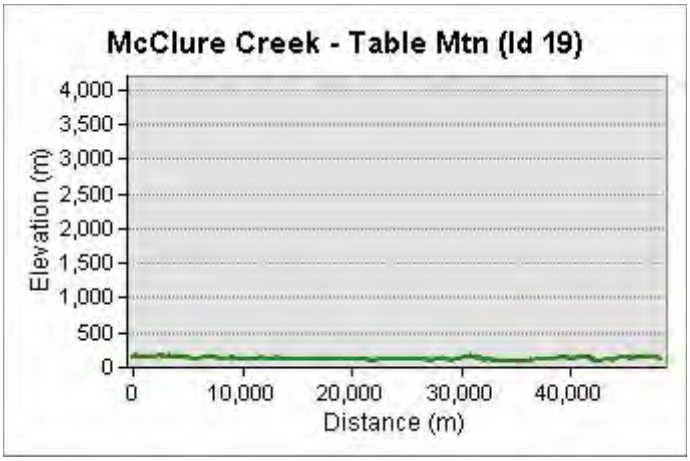
20,000
40,000
60,000
Distance (m)


McClure Creek - Table Mtn (Id 19)
Elevation (m)
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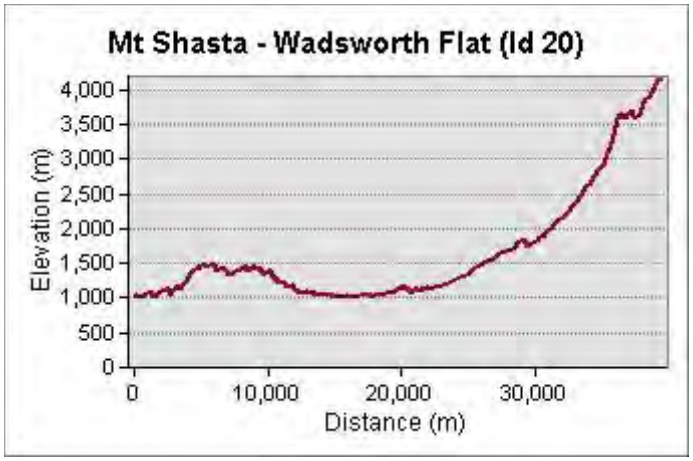
20,000
30,000
40,000
Distance (m)


Mt Shasta - Wadsworth Flat (Id 20)
Elevation (m)
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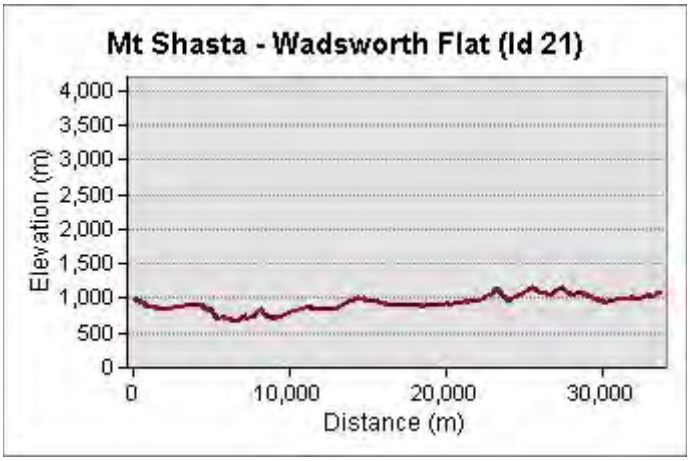
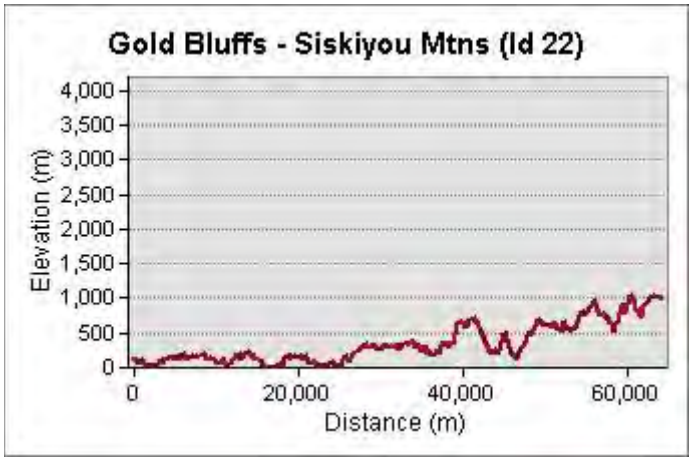
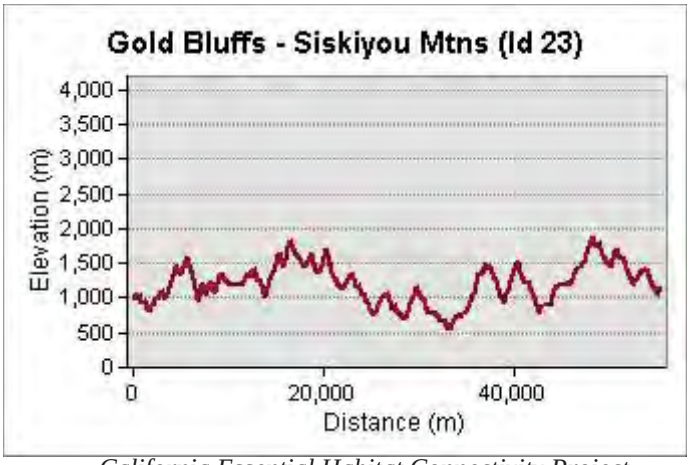
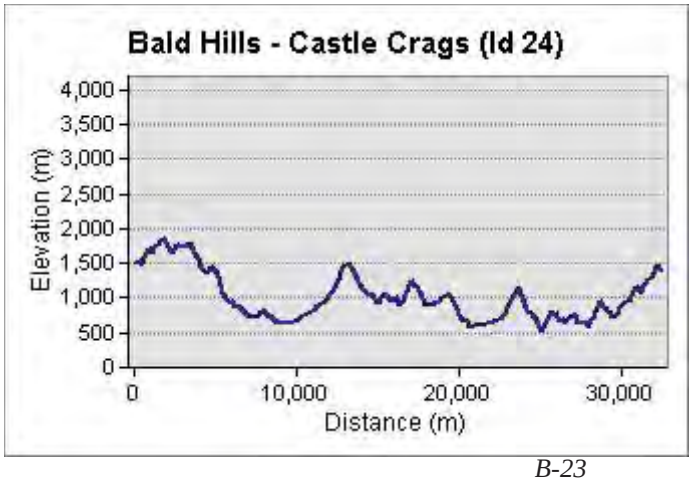
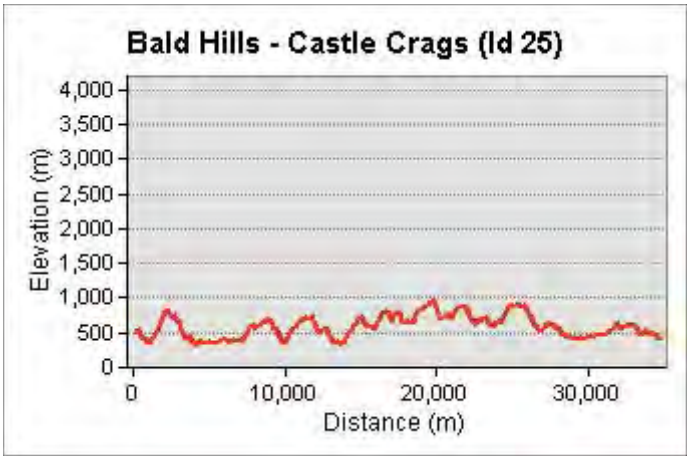
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

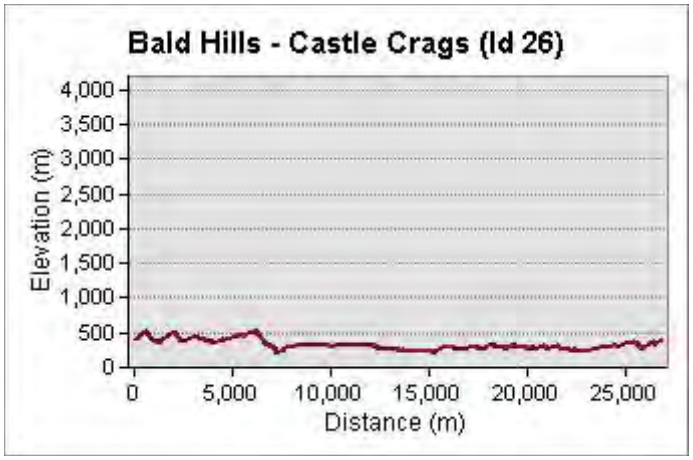

Mt Shasta - Wadsworth Flat (Id 21)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

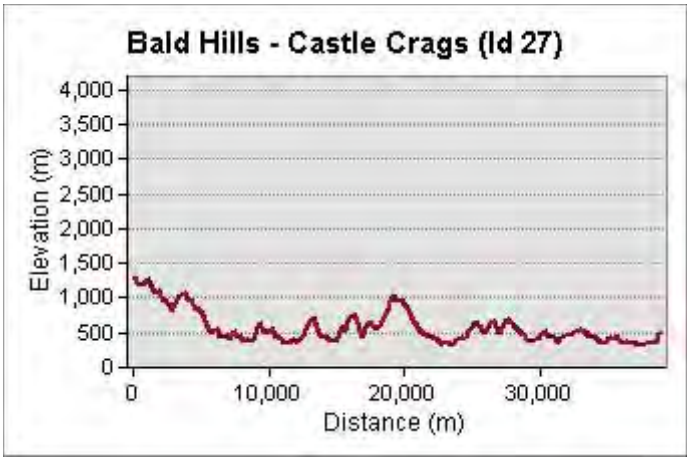

Gold Bluffs - Siskiyou Mtns (Id 22)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

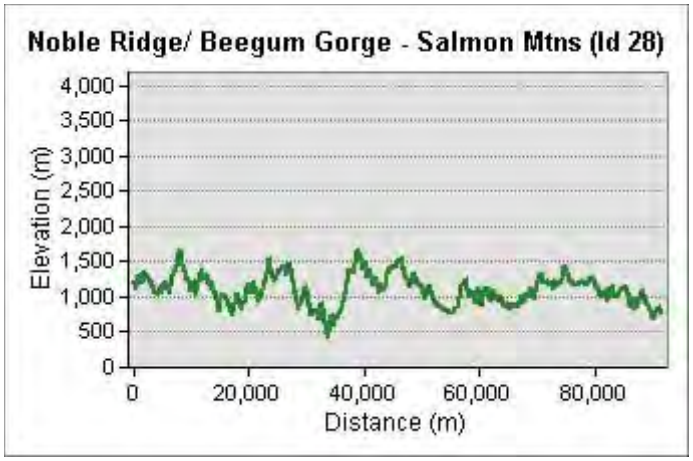

Gold Bluffs - Siskiyou Mtns (Id 23)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)

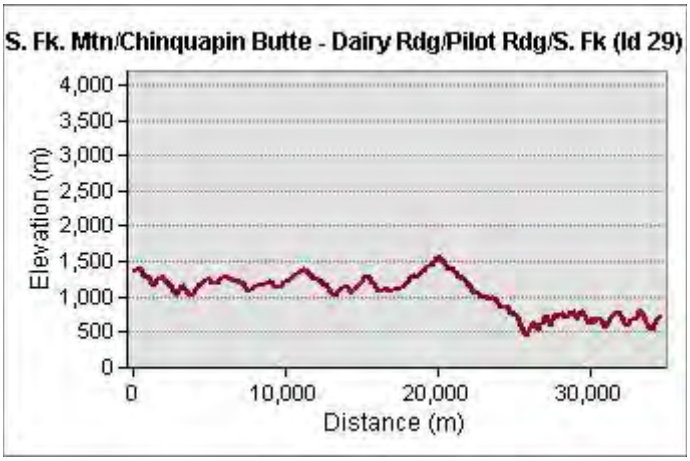

Bald Hills - Castle Crags (Id 24)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

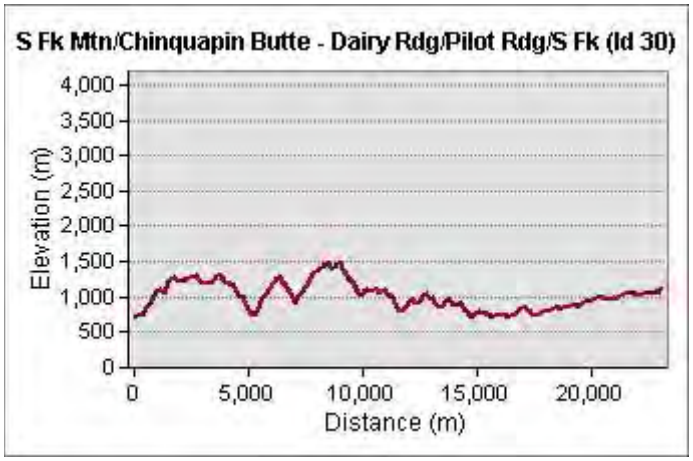

Bald Hills - Castle Crags (Id 25)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

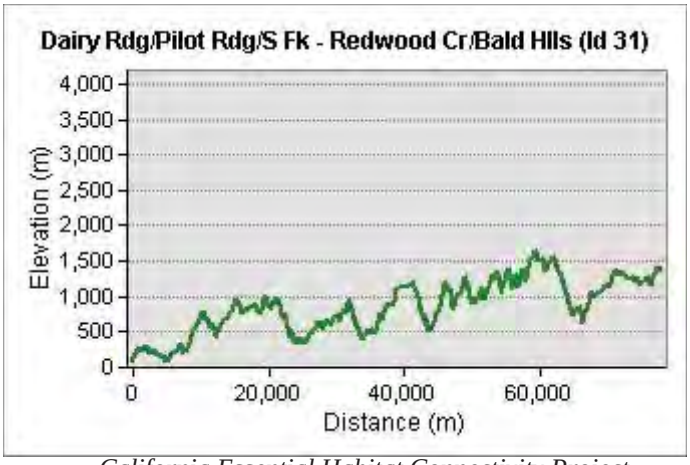

Bald Hills - Castle Crags (Id 26)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
25,000
Distance (m)

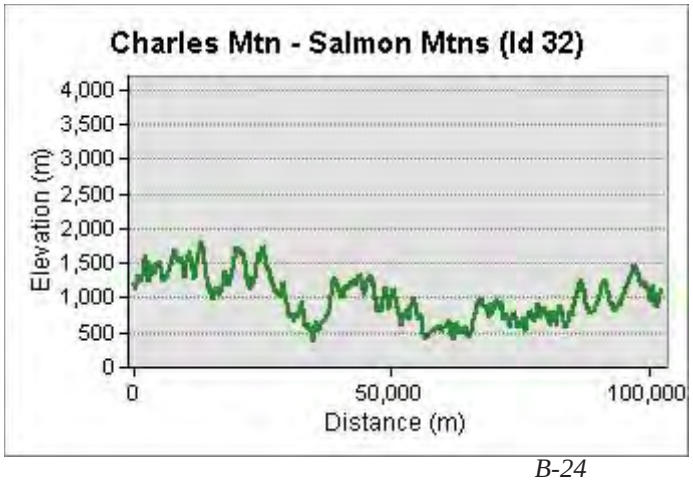

Bald Hills - Castle Crags (Id 27)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


Noble Ridge/ Beegum Gorge - Salmon Mtns (Id 28)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

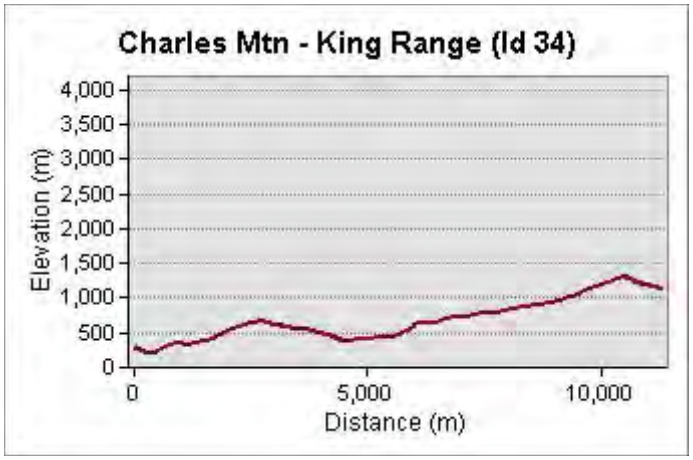

S. Fk. Mtn/Chinquapin Butte - Dairy Rdg/Pilot Rdg/S. Fk (Id 29)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

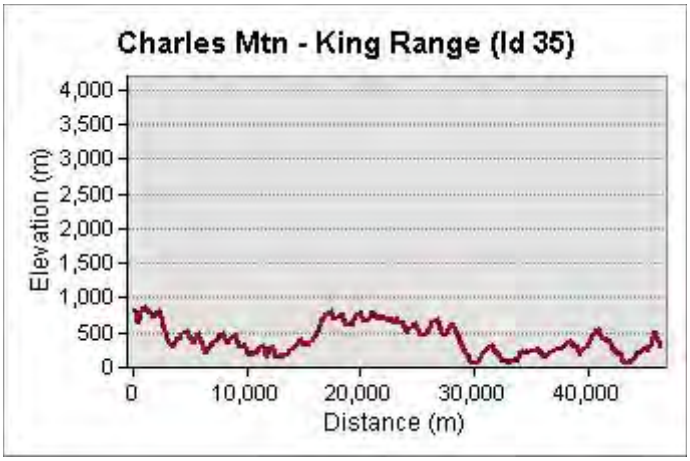

S Fk Mtn/Chinquapin Butte - Dairy Rdg/Pilot Rdg/S Fk (Id 30)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

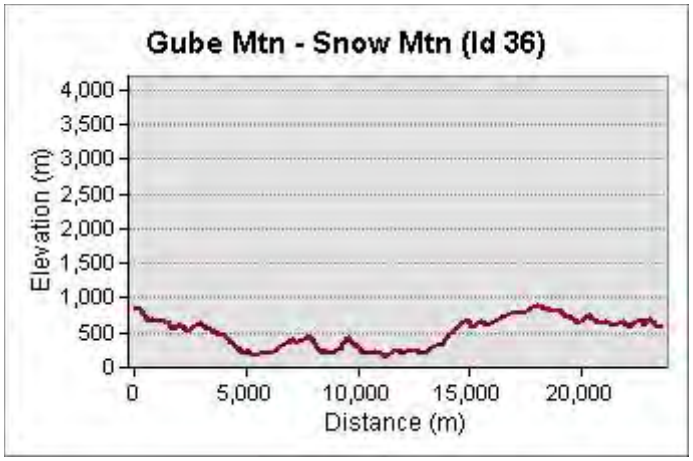

Dairy Rdg/Pilot Rdg/S Fk - Redwood Cr/Bald Hills (Id 31)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

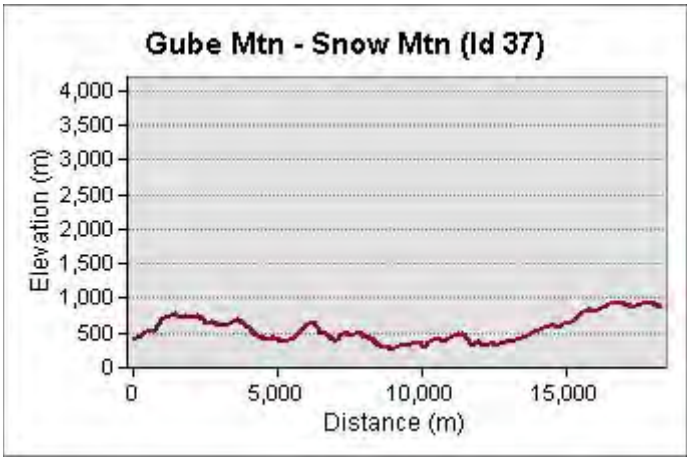

Charles Mtn - Salmon Mtns (Id 32)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
Distance (m)

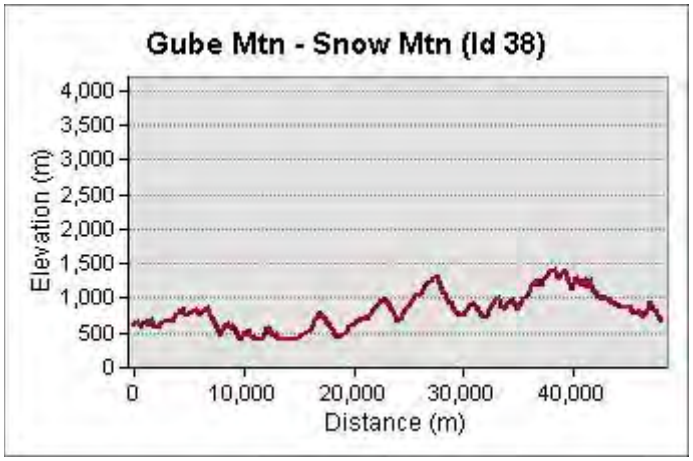
Sinkyone - Island Mtn (Id 33)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)

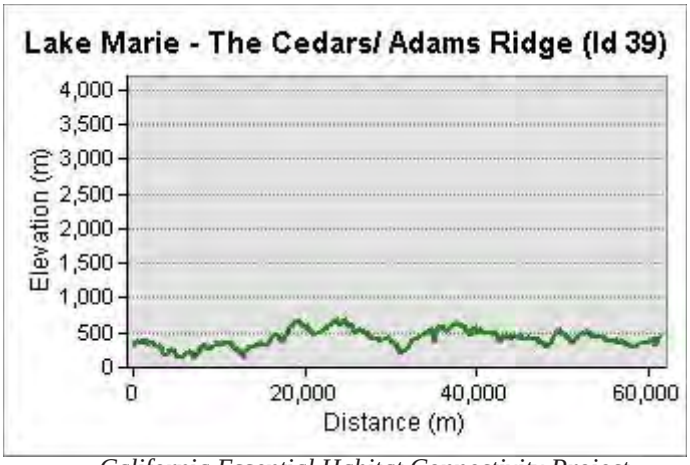

Charles Mtn - King Range (Id 34)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

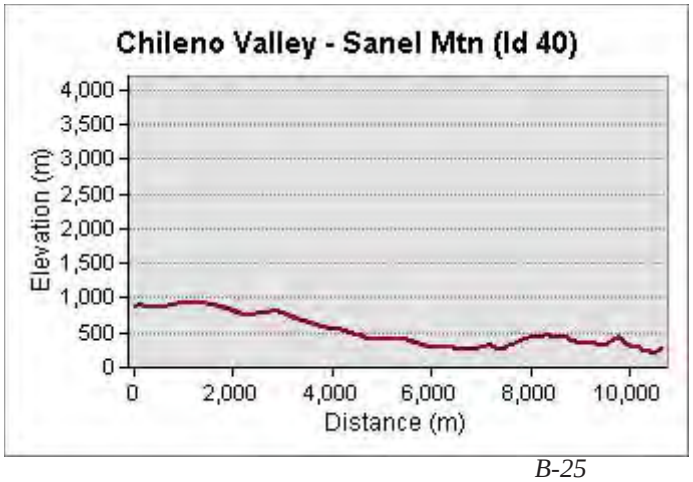

Charles Mtn - King Range (Id 35)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

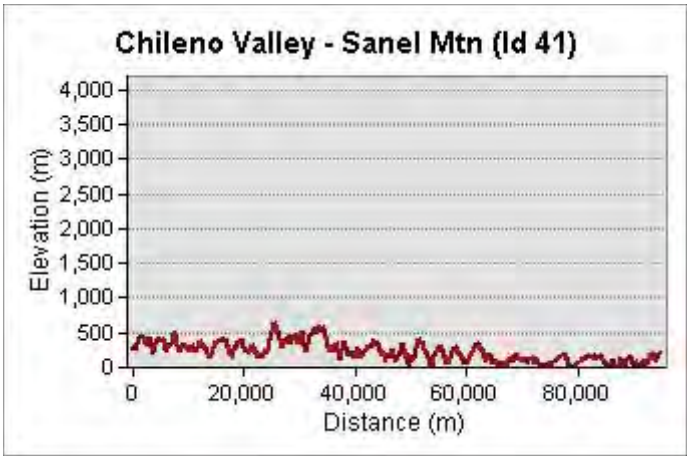

Gube Mtn - Snow Mtn (Id 36)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

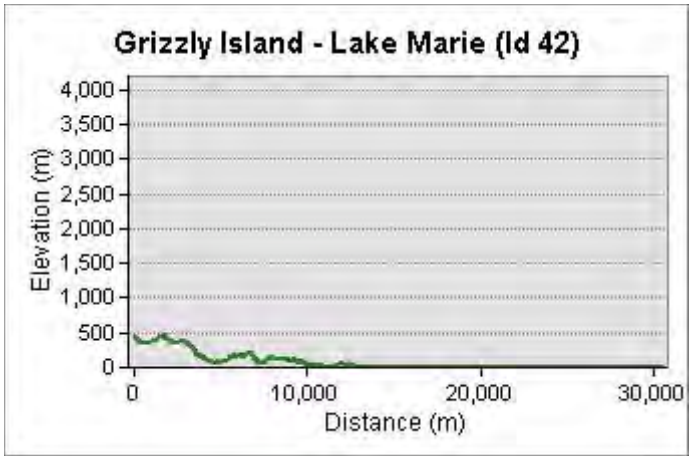

Gube Mtn - Snow Mtn (Id 37)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

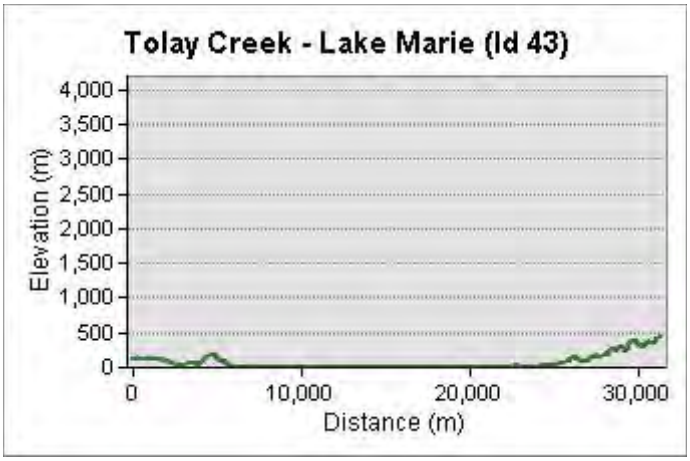

Gube Mtn - Snow Mtn (Id 38)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

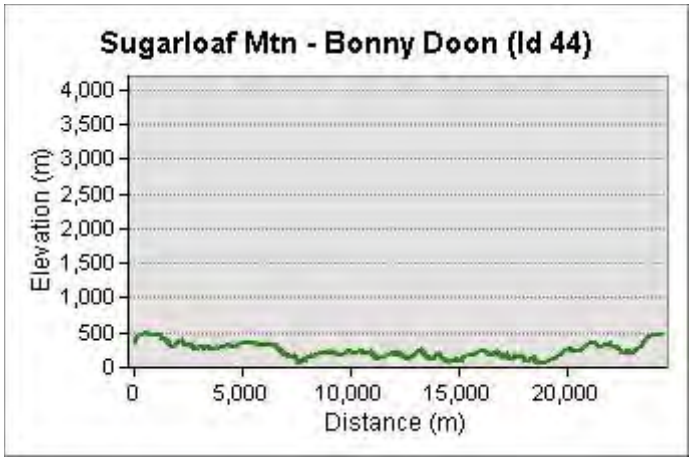

Lake Marie - The Cedars/ Adams Ridge (Id 39)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

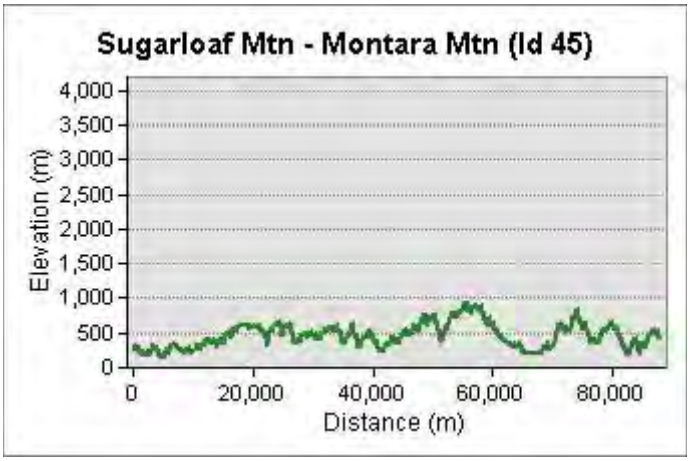

Chileno Valley - Sanel Mtn (Id 40)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
2,000
4,000
6,000
8,000
10,000
Distance (m)

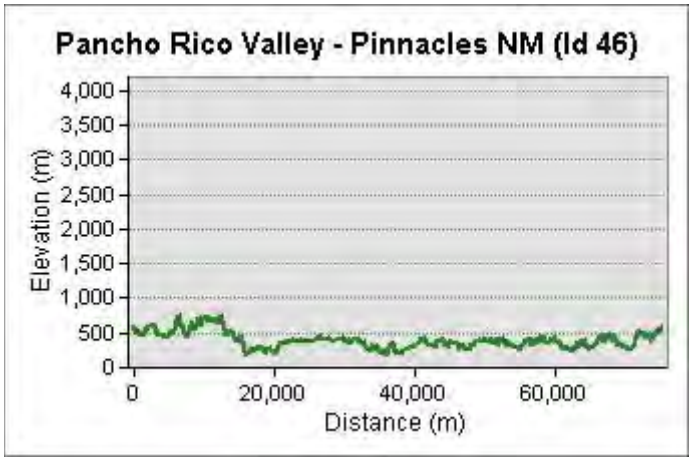

Chileno Valley - Sanel Mtn (Id 41)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

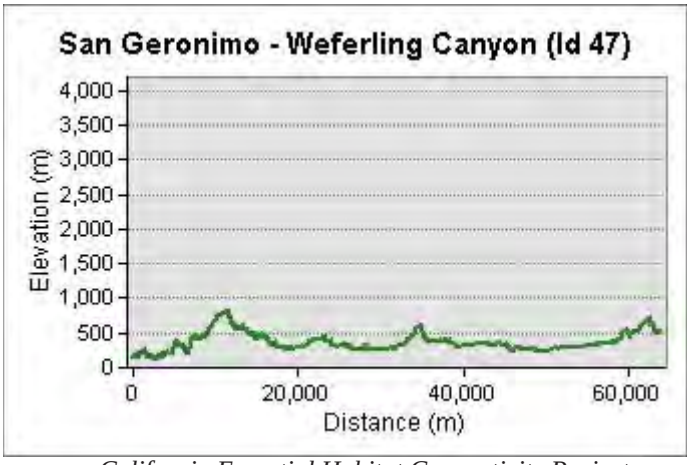

Grizzly Island - Lake Marie (Id 42)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

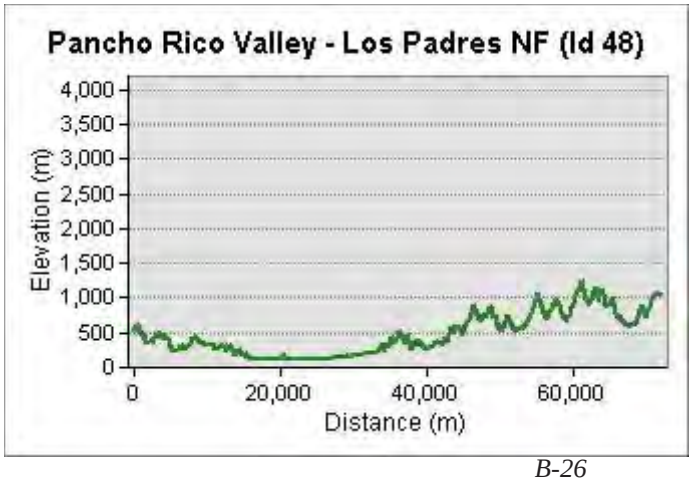

Tolay Creek - Lake Marie (Id 43)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

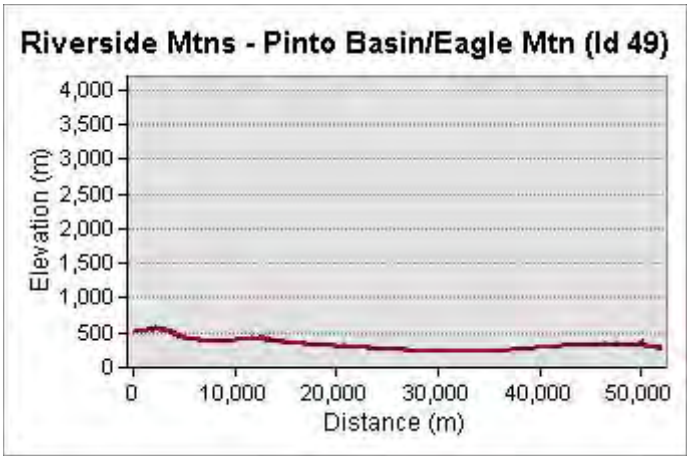

Sugarloaf Mtn - Bonny Doon (Id 44)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

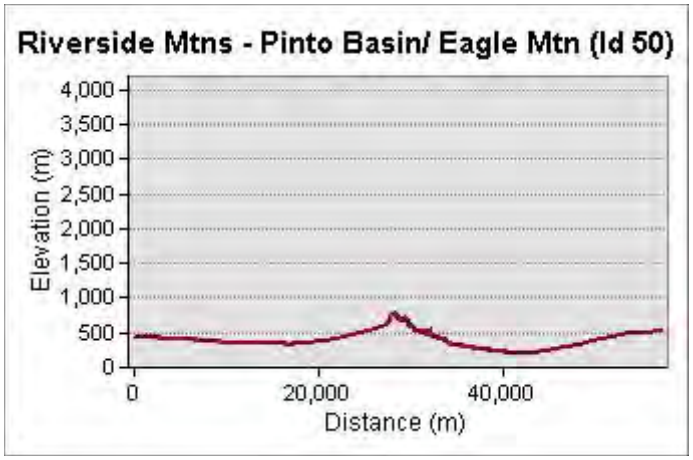

Sugarloaf Mtn - Montara Mtn (Id 45)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

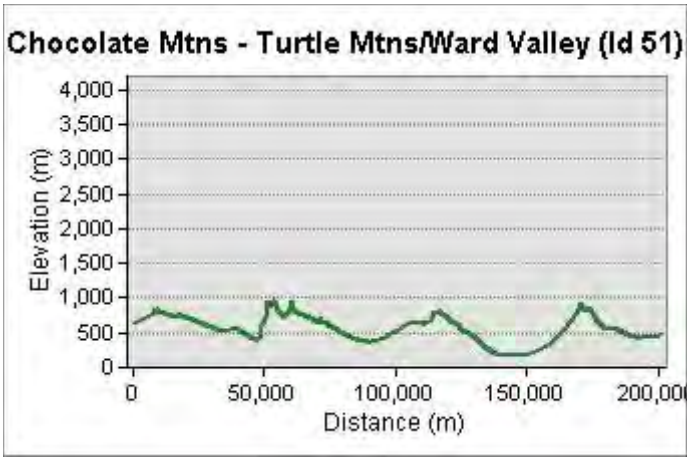

Pancho Rico Valley - Pinnacles NM (Id 46)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

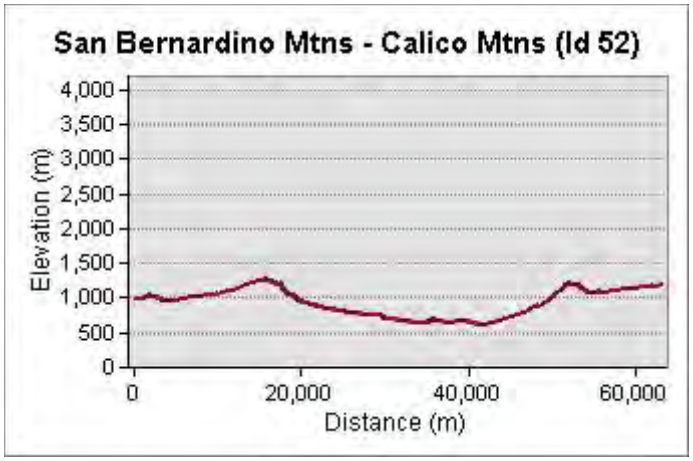

San Geronimo - Weferling Canyon (Id 47)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

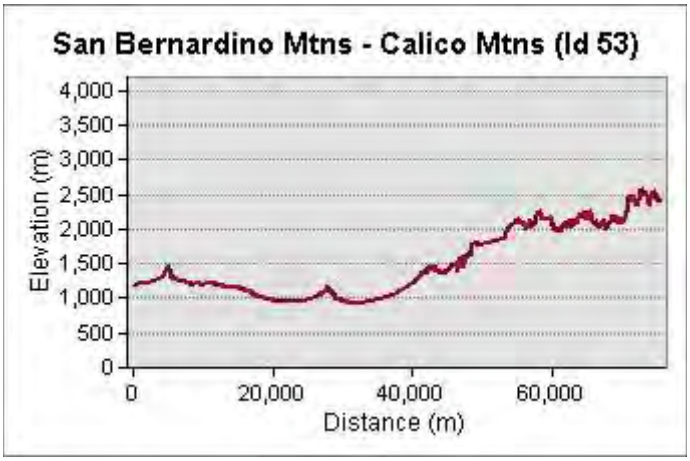

Pancho Rico Valley - Los Padres NF (Id 48)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

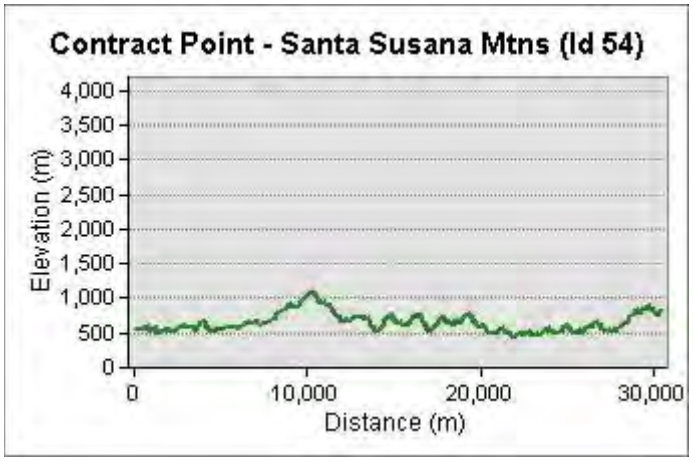

Riverside Mtns - Pinto Basin/Eagle Mtn (Id 49)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
50,000
Distance (m)

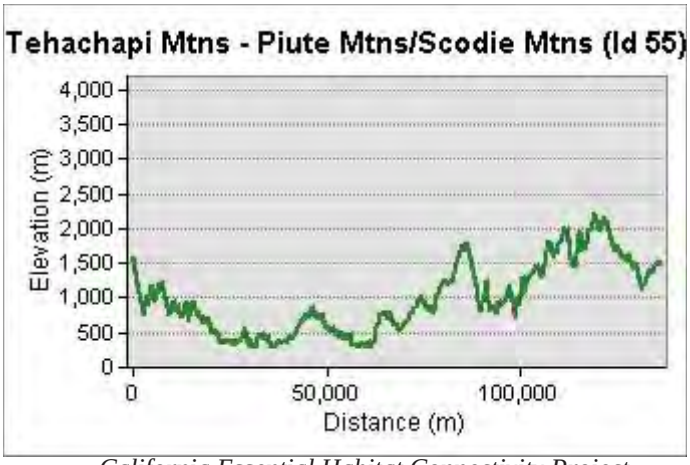

Riverside Mtns - Pinto Basin/ Eagle Mtn (Id 50)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)

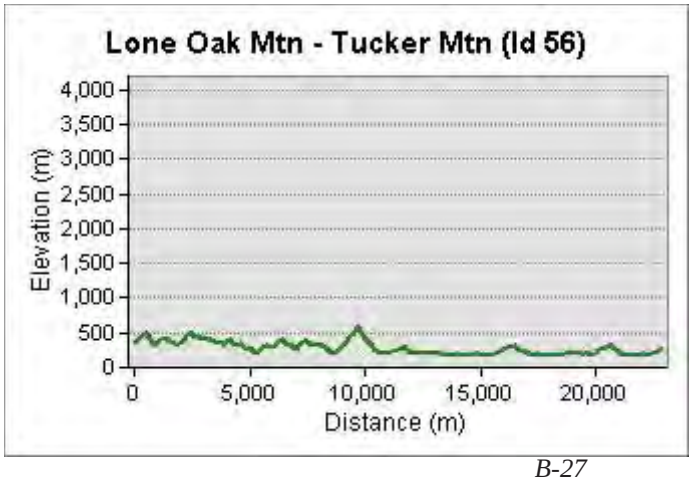

Chocolate Mtns - Turtle Mtns/Ward Valley (Id 51)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
150,000
200,000
Distance (m)

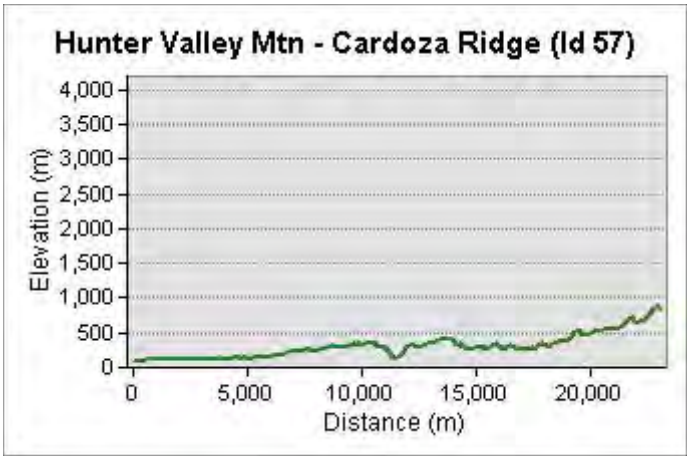

San Bernardino Mtns - Calico Mtns (Id 52)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

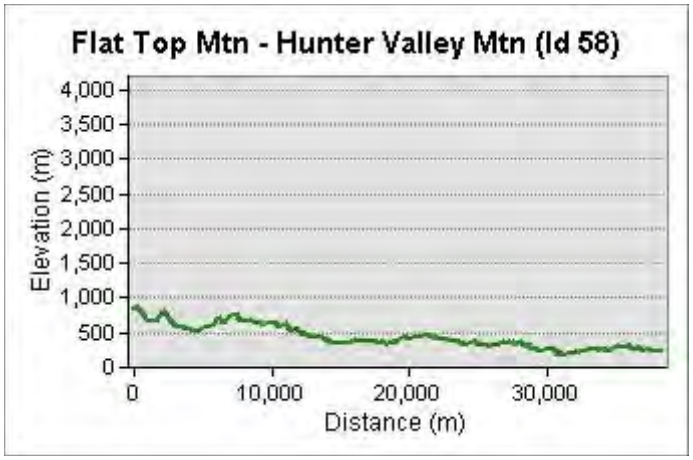

San Bernardino Mtns - Calico Mtns (Id 53)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)


Contract Point - Santa Susana Mtns (Id 54)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


Tehachapi Mtns - Piute Mtns/Scodie Mtns (Id 55)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
Distance (m)


Lone Oak Mtn - Tucker Mtn (Id 56)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)


Hunter Valley Mtn - Cardoza Ridge (Id 57)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)


Flat Top Mtn - Hunter Valley Mtn (Id 58)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

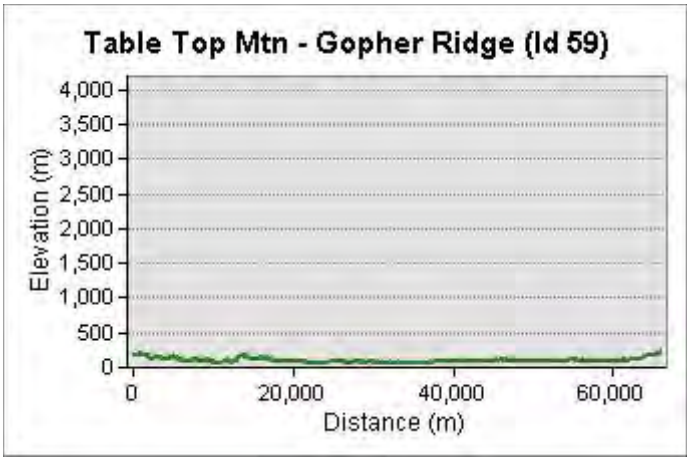
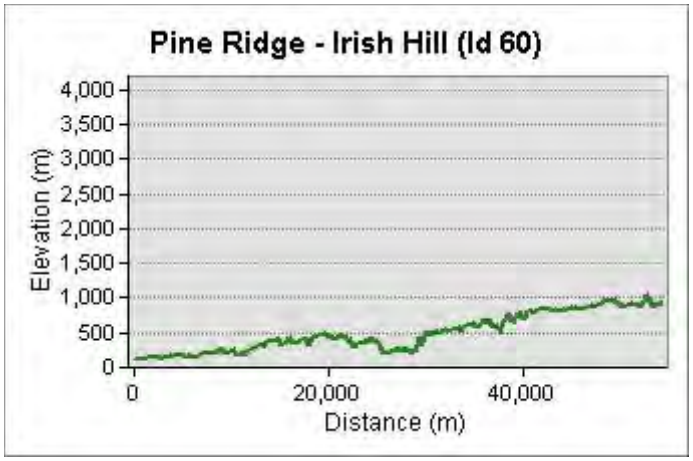
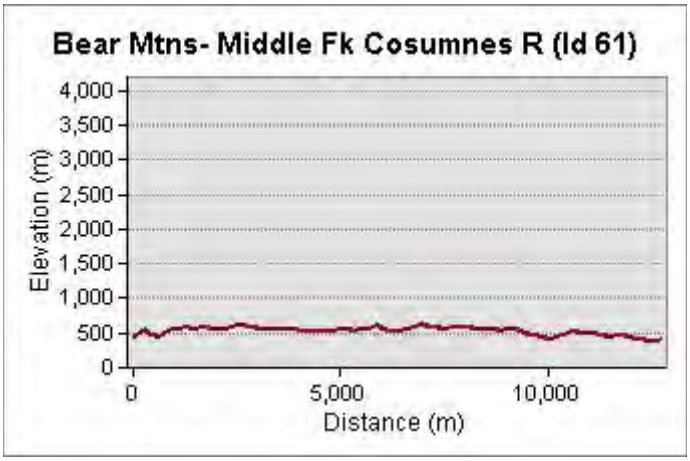
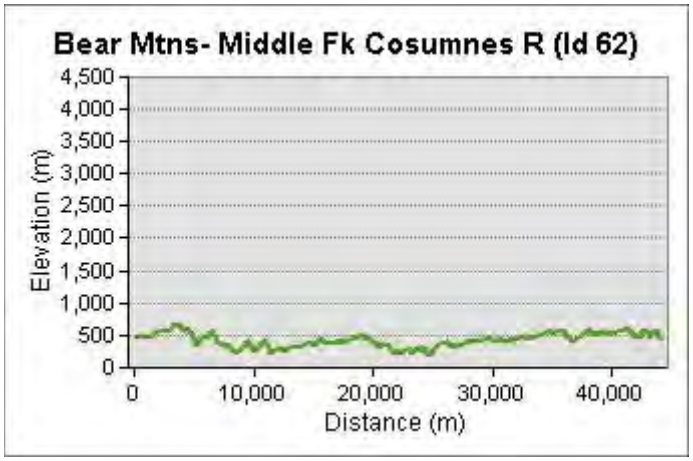
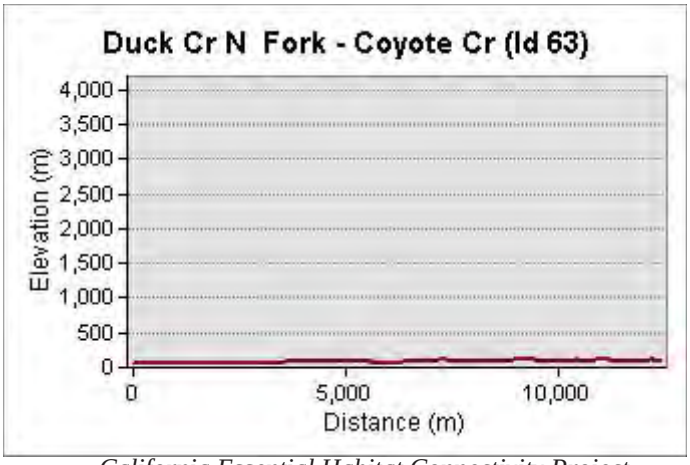


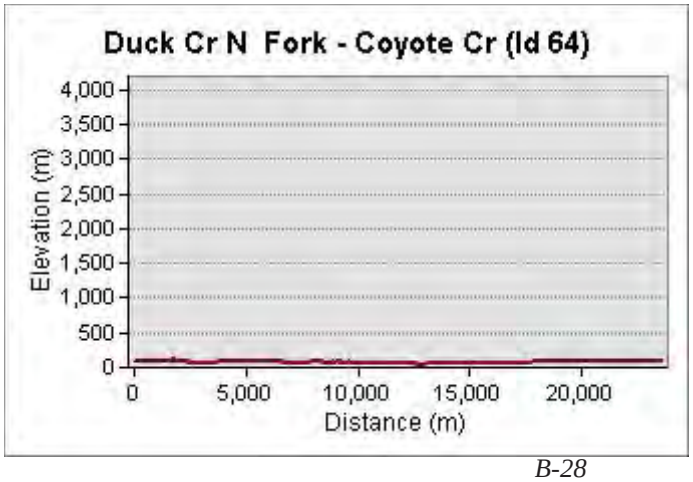
Table Top Mtn - Gopher Ridge (Id 59)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

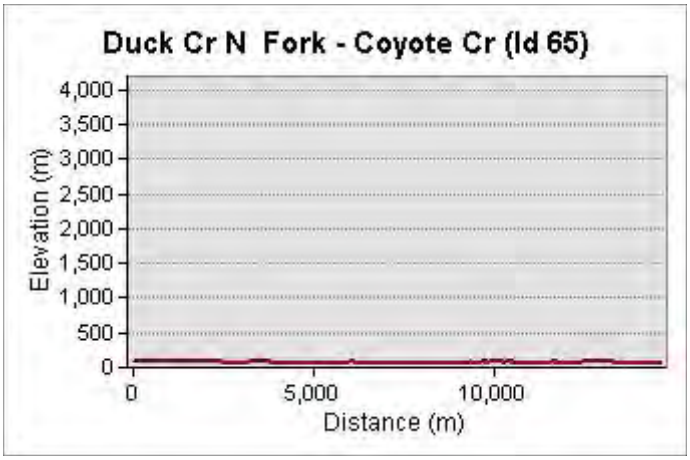

Pine Ridge - Irish Hill (Id 60)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)

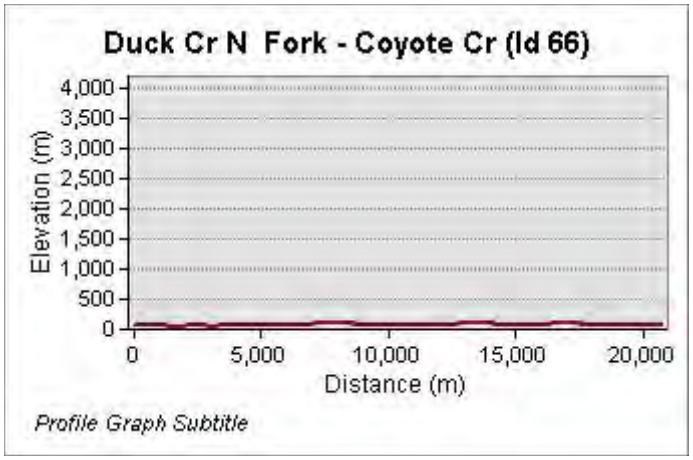

Bear Mtns- Middle Fk Cosumnes R (Id 61)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

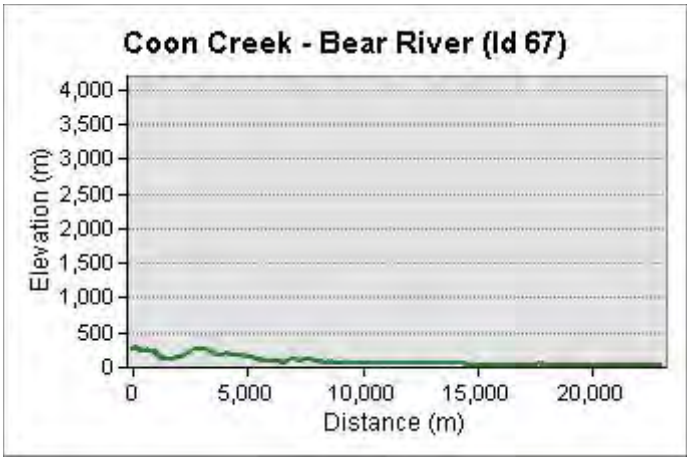

Bear Mtns- Middle Fk Cosumnes R (Id 62)
Elevation (m)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

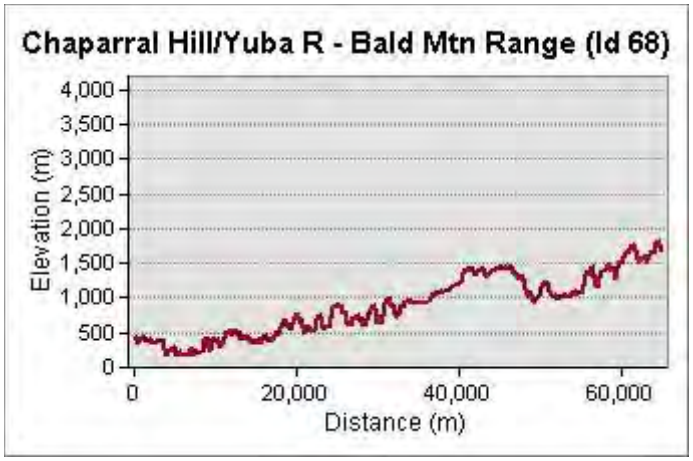

Duck Cr N Fork - Coyote Cr (Id 63)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

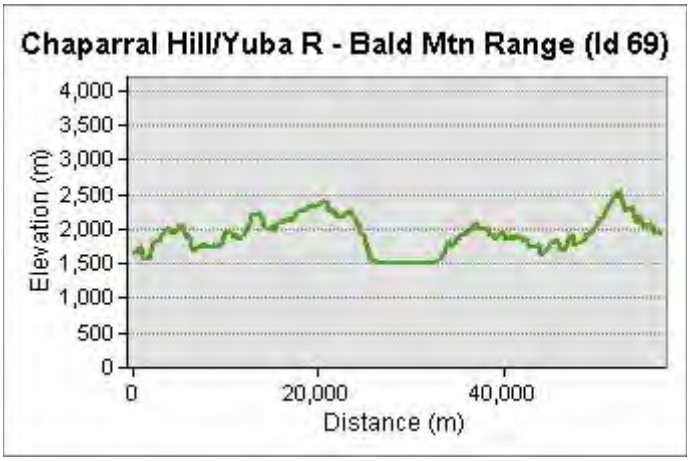

Duck Cr N Fork - Coyote Cr (Id 64)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

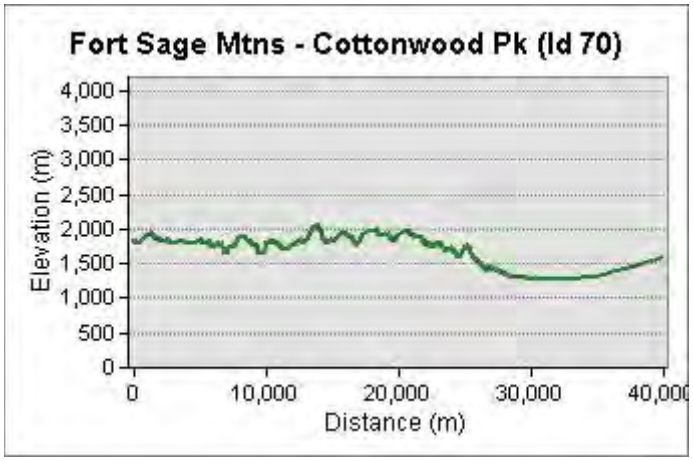

Duck Cr N Fork - Coyote Cr (Id 65)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

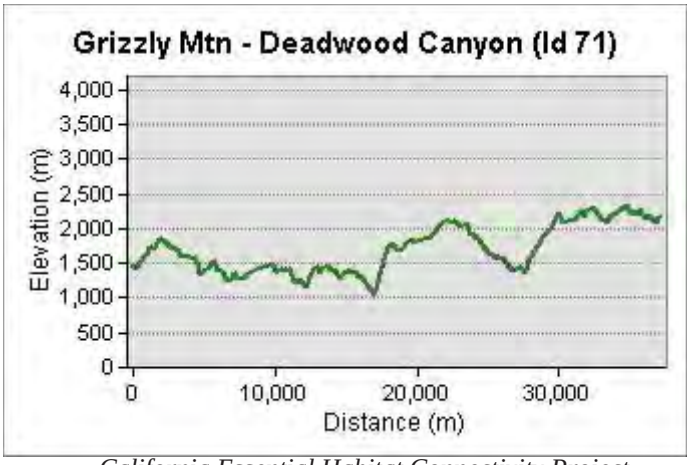

Duck Cr N Fork - Coyote Cr (Id 66)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)
Profile Graph Subtitle

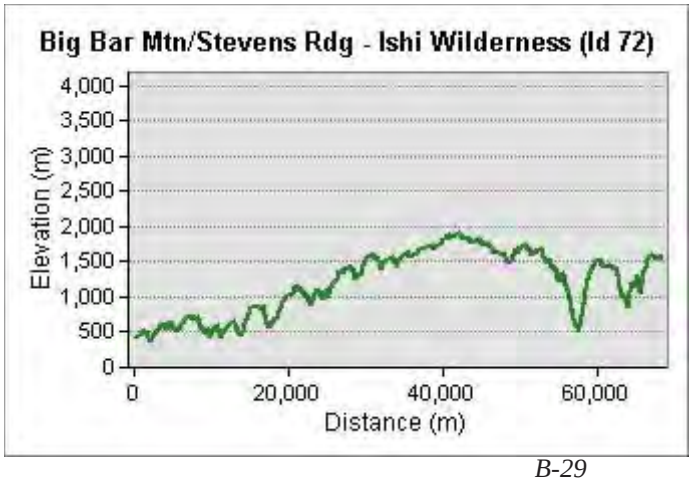

Coon Creek - Bear River (Id 67)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)


Chaparral Hill/Yuba R - Bald Mtn Range (Id 68)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)


Chaparral Hill/Yuba R - Bald Mtn Range (Id 69)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)


Fort Sage Mtns - Cottonwood Pk (Id 70)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)


Grizzly Mtn - Deadwood Canyon (Id 71)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


Big Bar Mtn/Stevens Rdg - Ishi Wilderness (Id 72)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

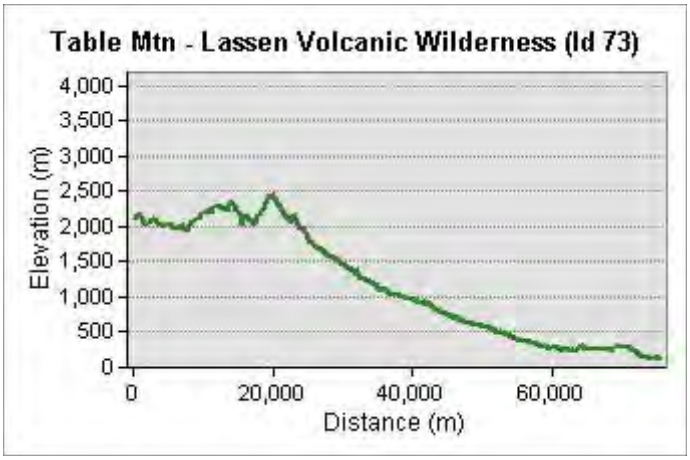
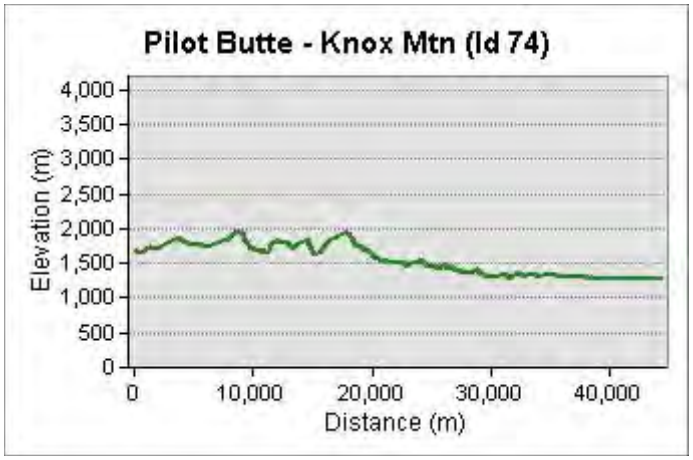
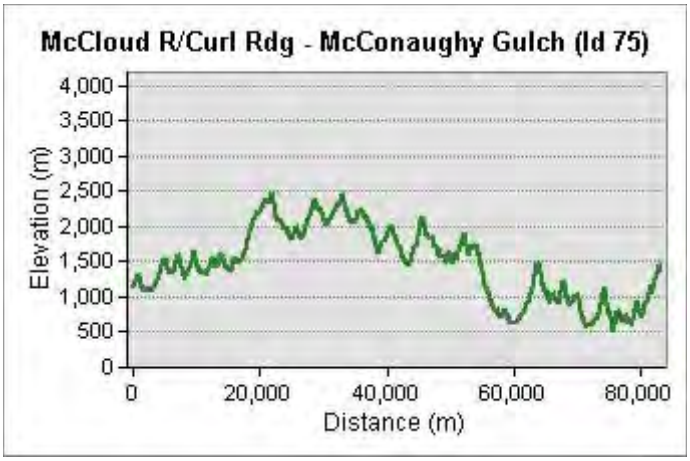
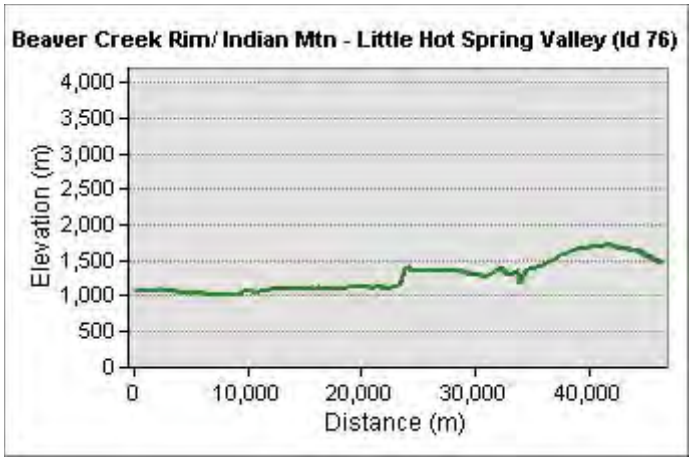
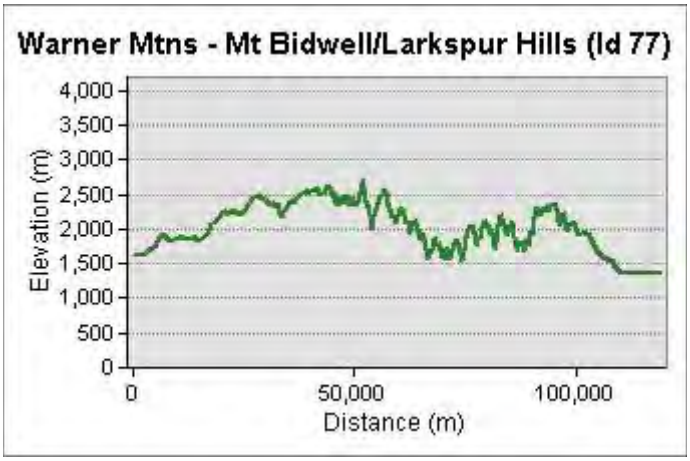


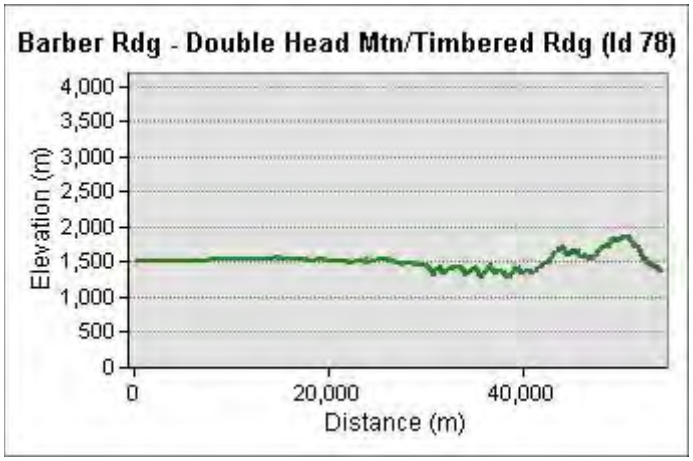
Table Mtn - Lassen Volcanic Wilderness (Id 73)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

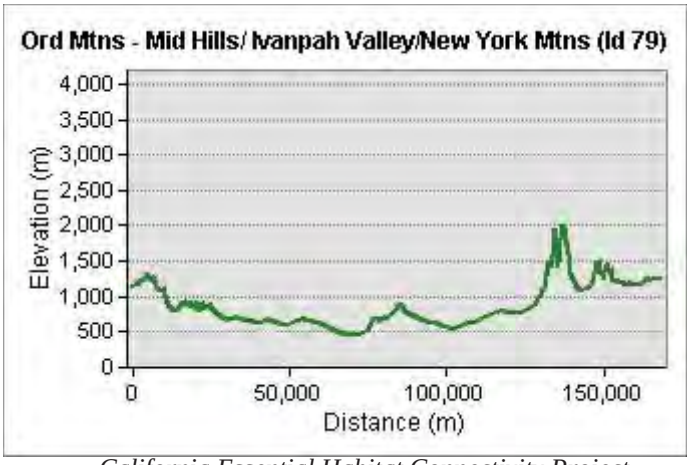

Pilot Butte - Knox Mtn (Id 74)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

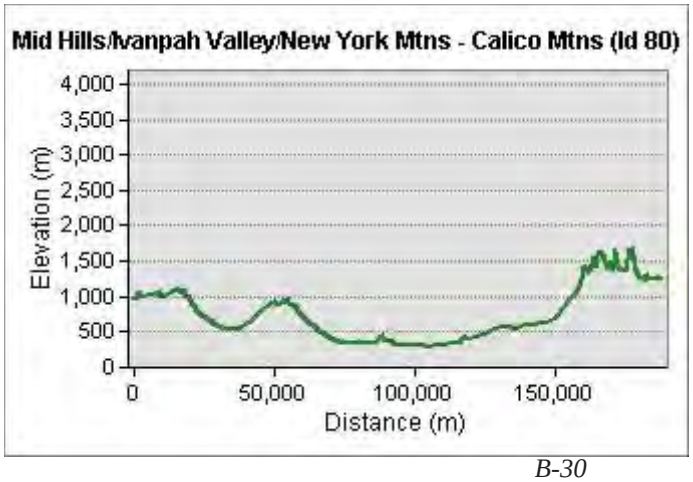

McCloud R/Curl Rdg - McConaughy Gulch (Id 75)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

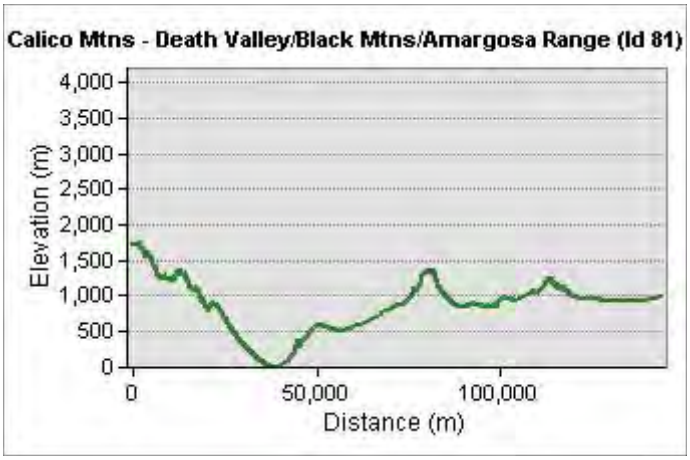

Beaver Creek Rim/ Indian Mtn - Little Hot Spring Valley (Id 76)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

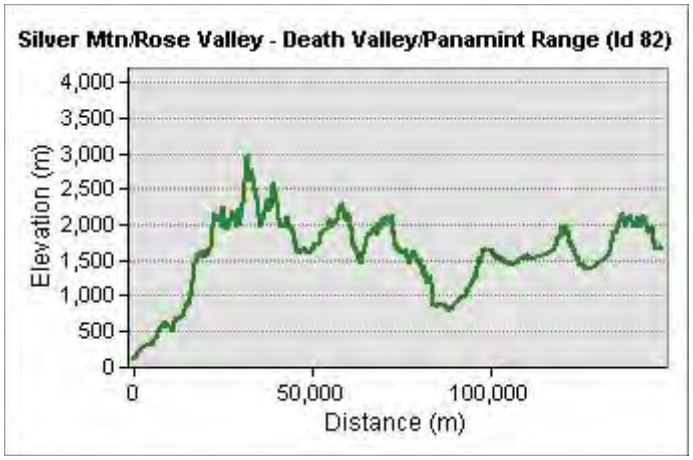

Warner Mtns - Mt Bidwell/Larkspur Hills (Id 77)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
Distance (m)

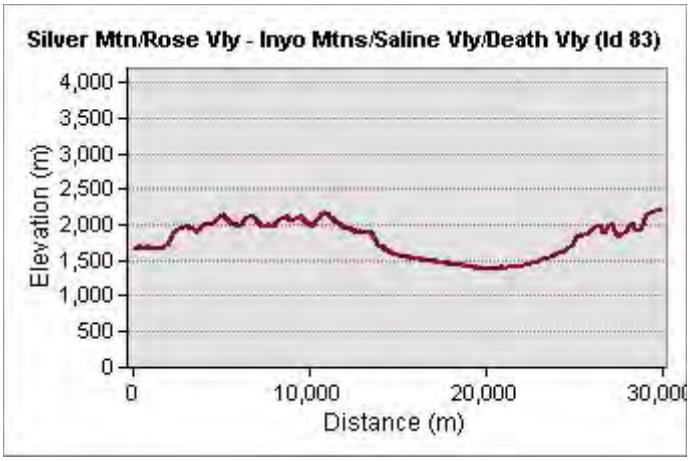

Barber Rdg - Double Head Mtn/Timbered Rdg (Id 78)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)

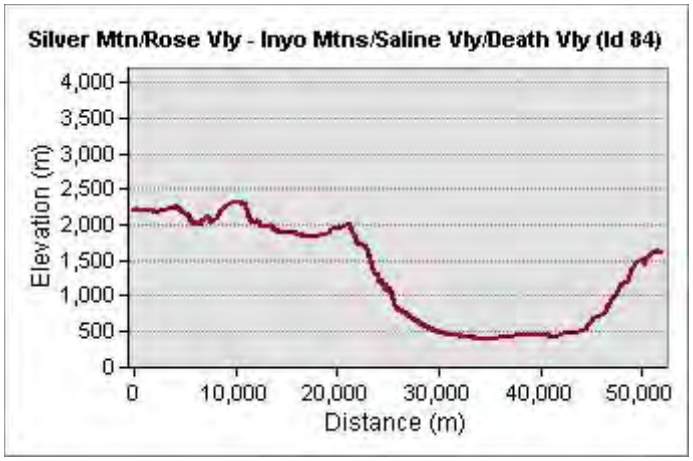

Ord Mtns - Mid Hills/ Ivanpah Valley/New York Mtns (Id 79)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
150,000
Distance (m)

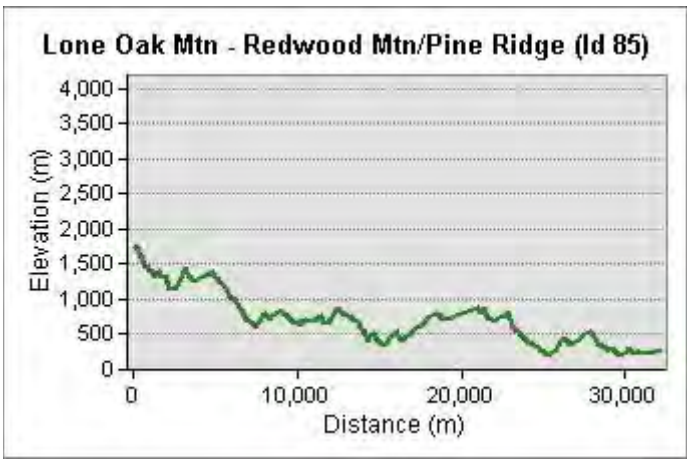

Mid Hills/Ivanpah Valley/New York Mtns - Calico Mtns (Id 80)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
150,000
Distance (m)

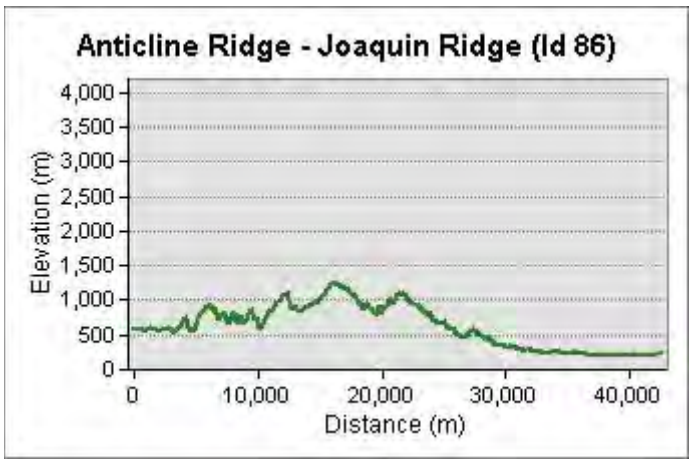

Calico Mtns - Death Valley/Black Mtns/Amargosa Range (Id 81)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
Distance (m)

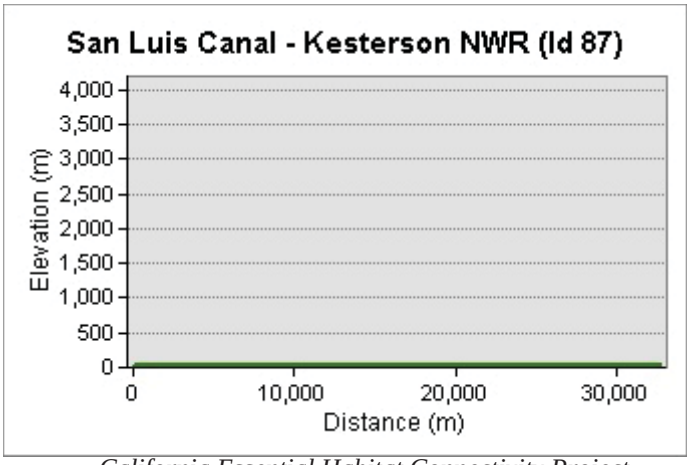

Silver Mtn/Rose Valley - Death Valley/Panamint Range (Id 82)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
Distance (m)

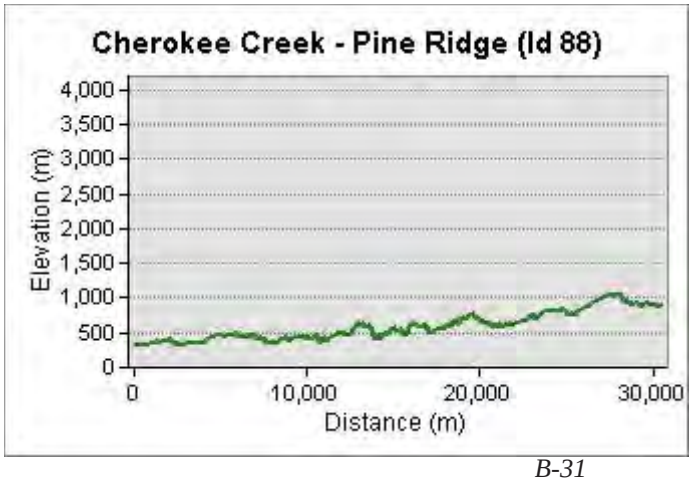

Silver Mtn/Rose Vly - Inyo Mtns/Saline Vly/Death Vly (Id 83)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

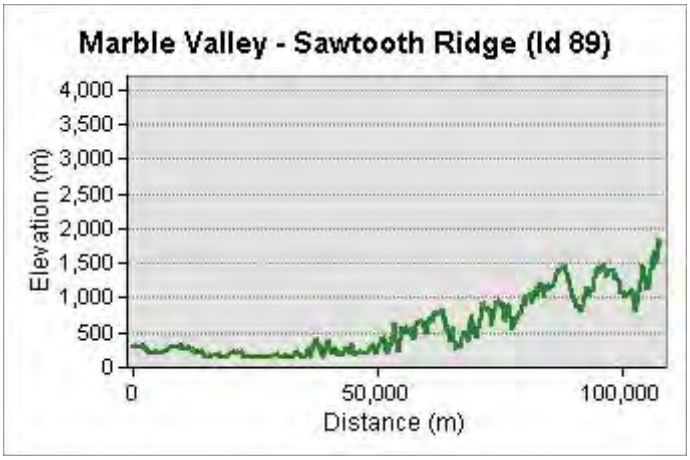

Silver Mtn/Rose Vly - Inyo Mtns/Saline Vly/Death Vly (Id 84)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
50,000
Distance (m)

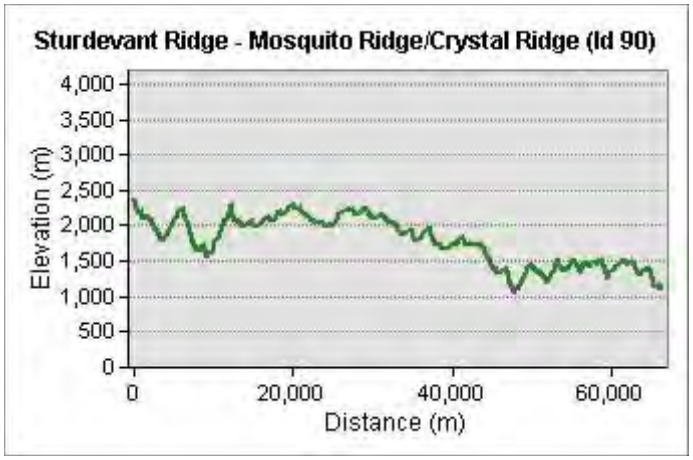

Lone Oak Mtn - Redwood Mtn/Pine Ridge (Id 85)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

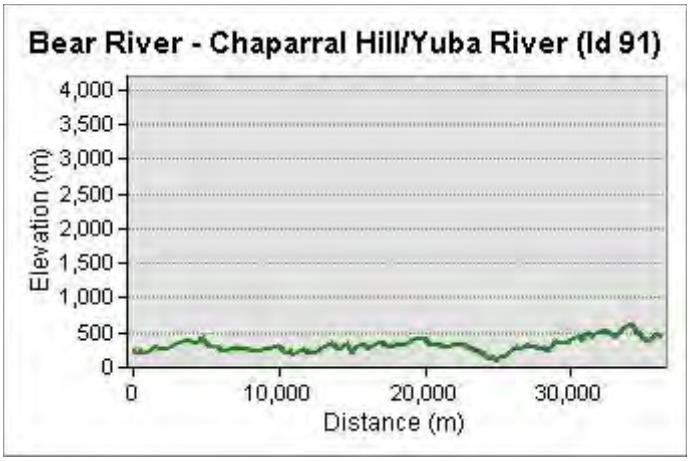

Anticline Ridge - Joaquin Ridge (Id 86)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

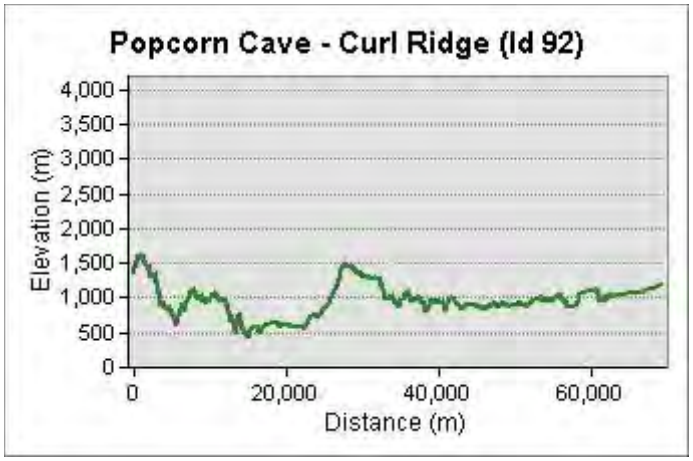

San Luis Canal - Kesterson NWR (Id 87)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

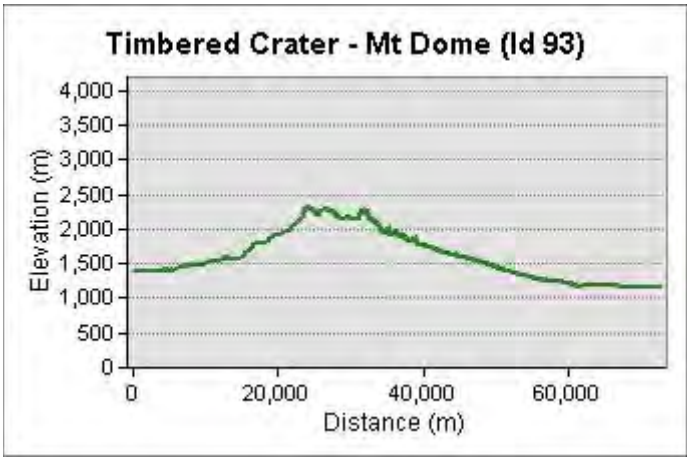

Cherokee Creek - Pine Ridge (Id 88)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

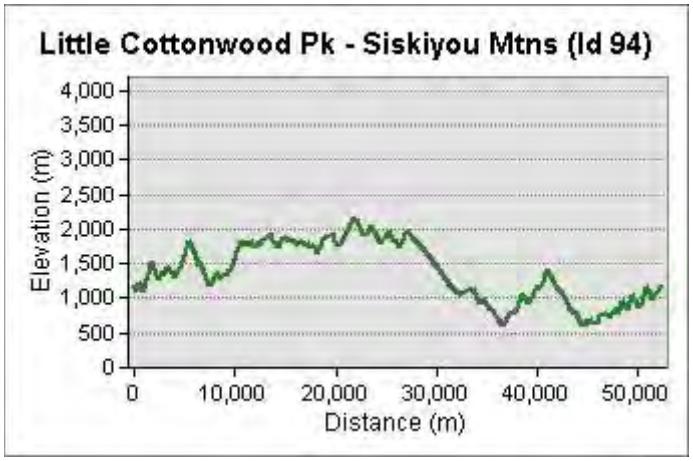

Marble Valley - Sawtooth Ridge (Id 89)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
Distance (m)

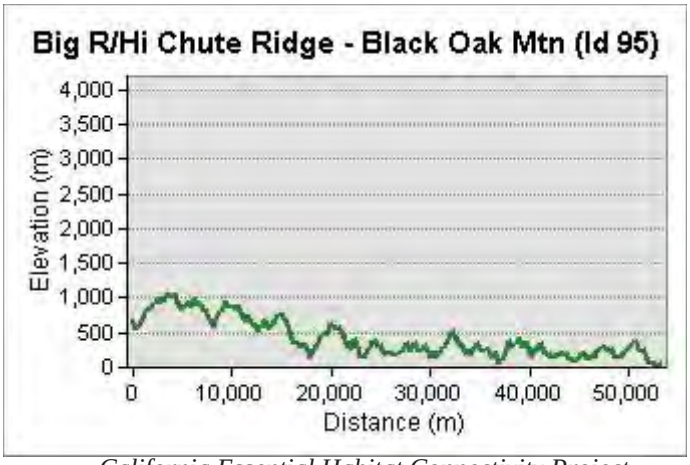

Sturdevant Ridge - Mosquito Ridge/Crystal Ridge (Id 90)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

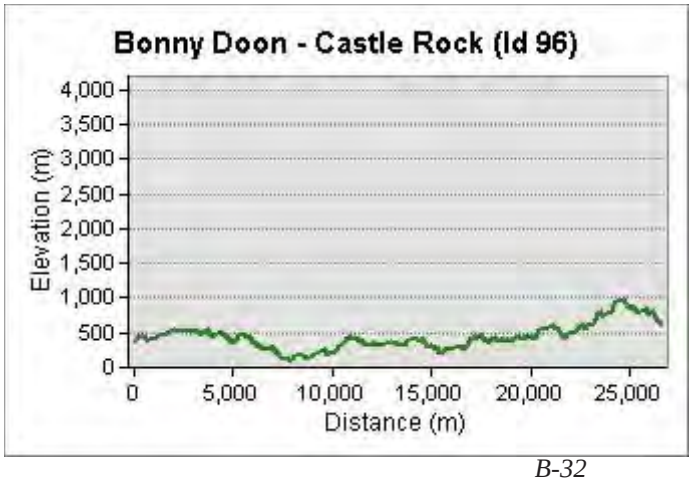

Bear River - Chaparral Hill/Yuba River (Id 91)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

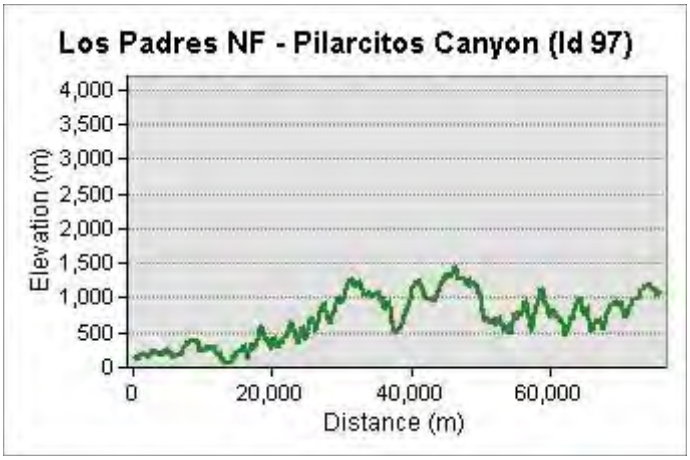

Popcorn Cave - Curl Ridge (Id 92)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

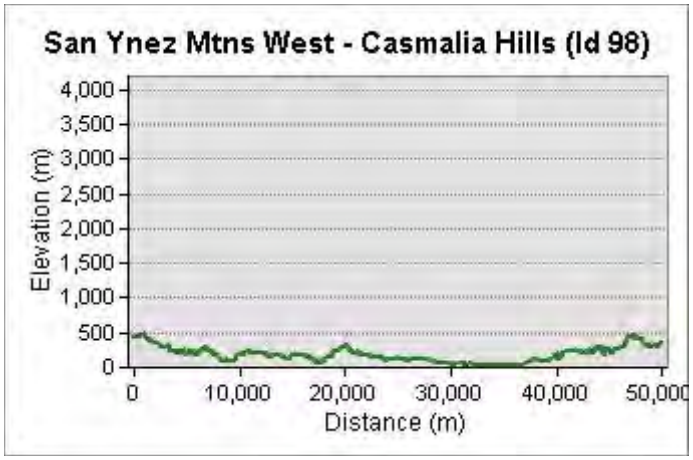

Timbered Crater - Mt Dome (Id 93)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

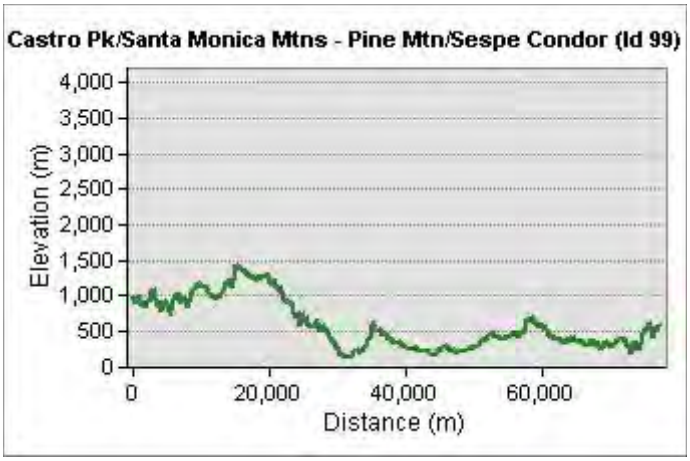

Little Cottonwood Pk - Siskiyou Mtns (Id 94)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
50,000
Distance (m)

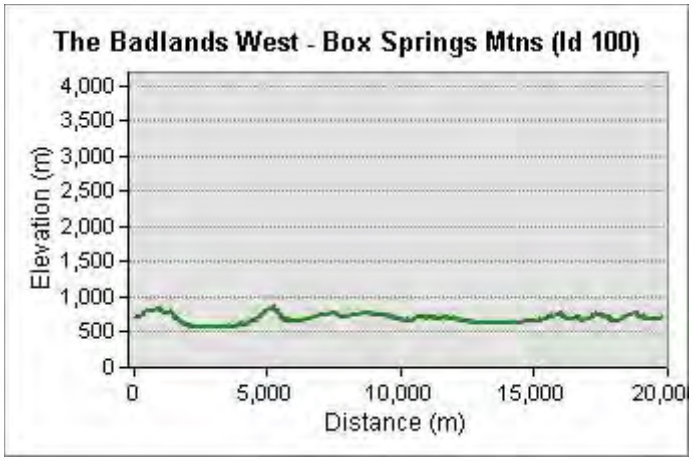

Big R/Hi Chute Ridge - Black Oak Mtn (Id 95)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
50,000
Distance (m)

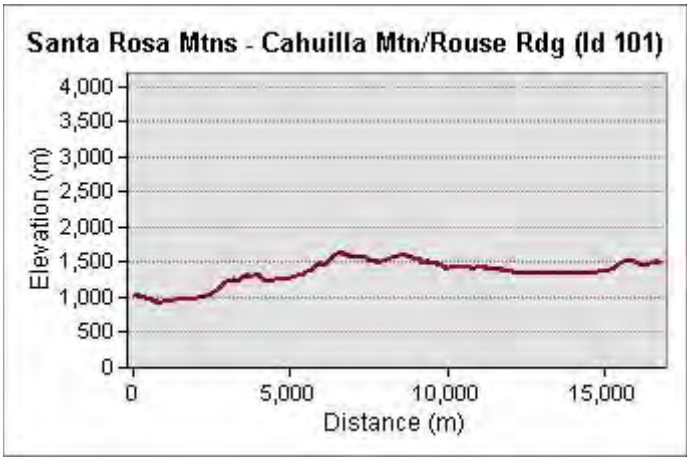

Bonny Doon - Castle Rock (Id 96)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
25,000
Distance (m)

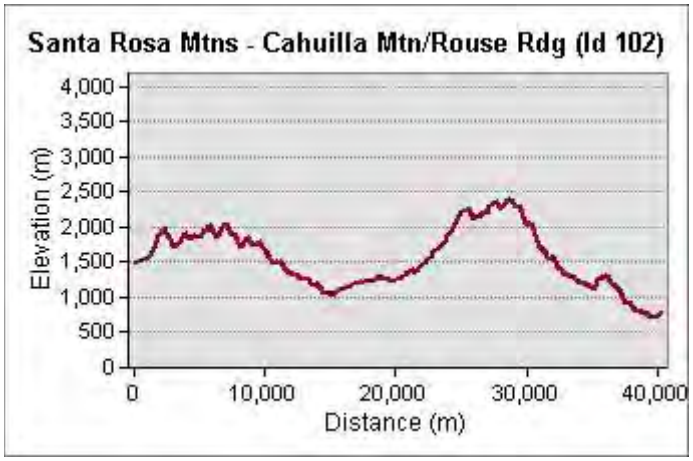

Los Padres NF - Pilarcitos Canyon (Id 97)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

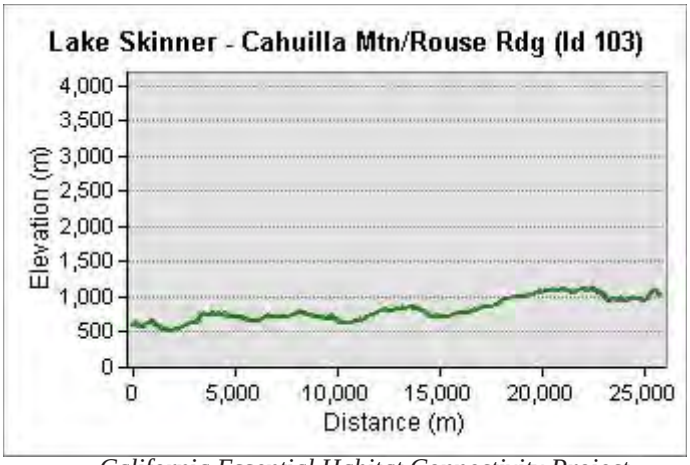

San Ynez Mtns West - Casmalia Hills (Id 98)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
50,000
Distance (m)

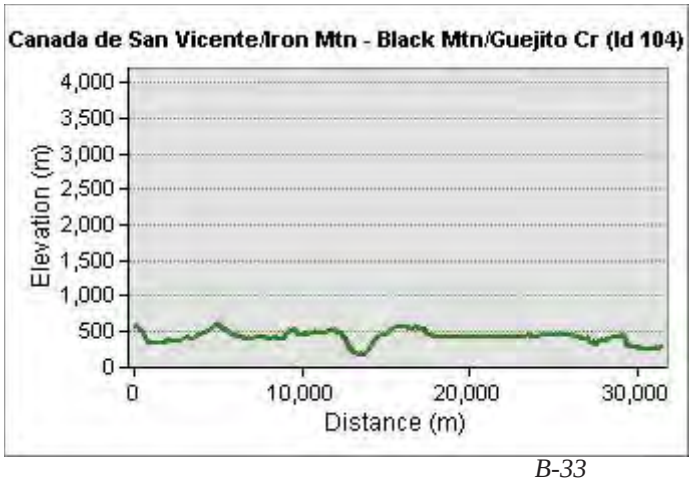

Castro Pk/Santa Monica Mtns - Pine Mtn/Sespe Condor (Id 99)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

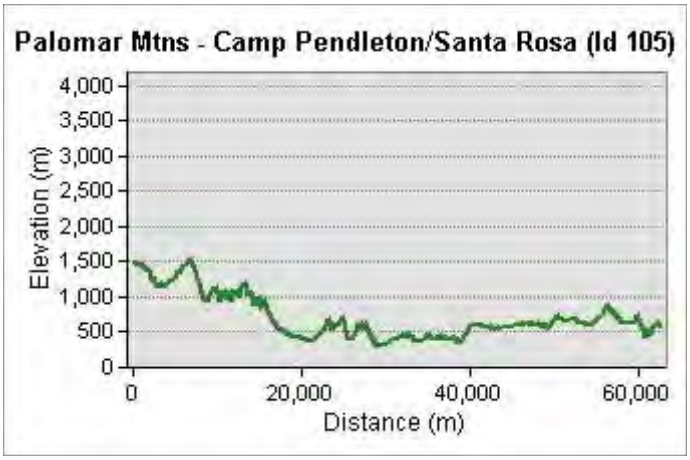

The Badlands West - Box Springs Mtns (Id 100)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,00
Distance (m)

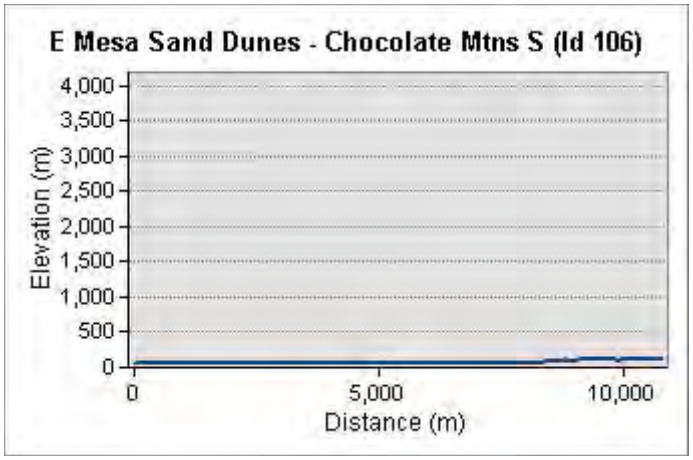

Santa Rosa Mtns - Cahuilla Mtn/Rouse Rdg (Id 101)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

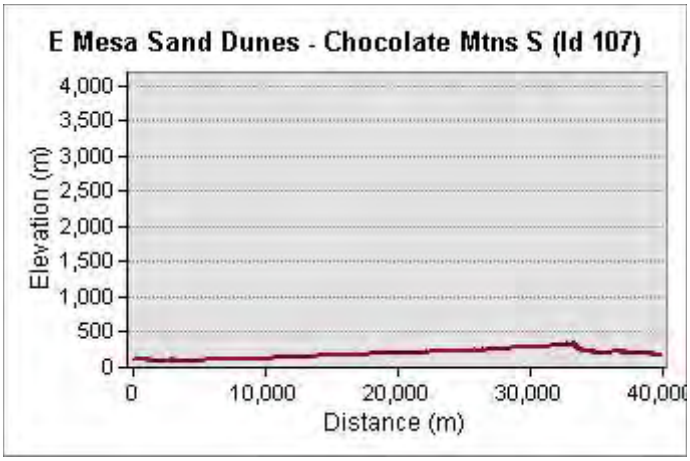

Santa Rosa Mtns - Cahuilla Mtn/Rouse Rdg (Id 102)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

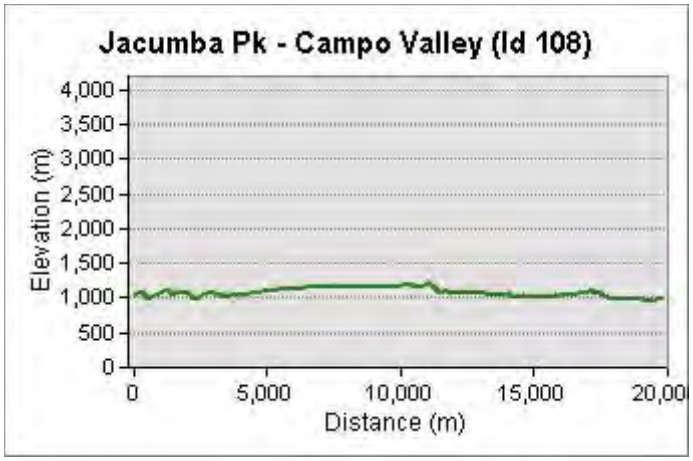

Lake Skinner - Cahuilla Mtn/Rouse Rdg (Id 103)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
25,000
Distance (m)

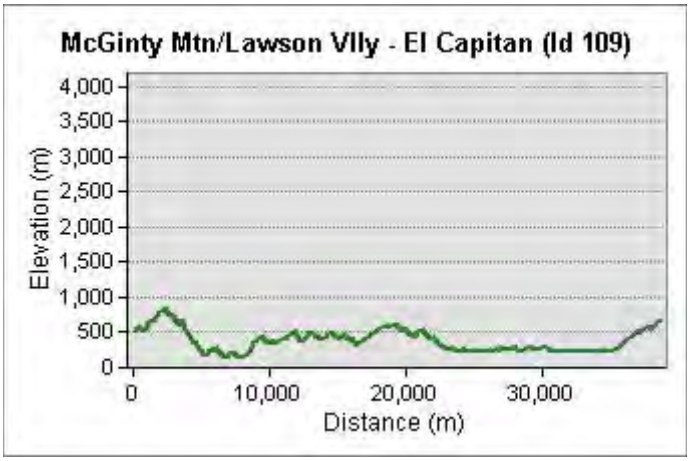

Canada de San Vicente/Iron Mtn - Black Mtn/Guejito Cr (Id 104)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

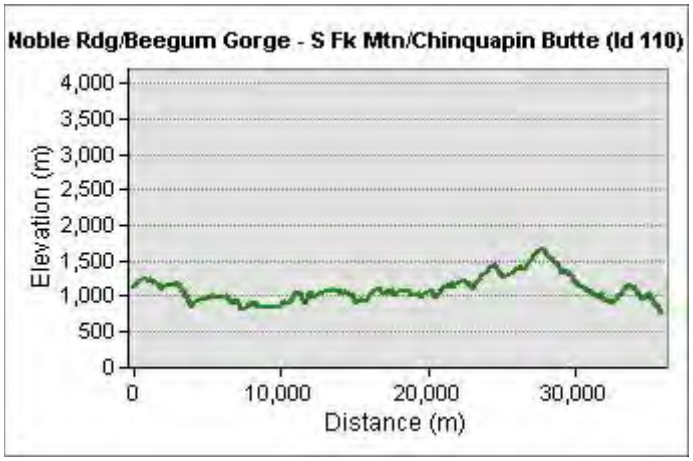

Palomar Mtns - Camp Pendleton/Santa Rosa (Id 105)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

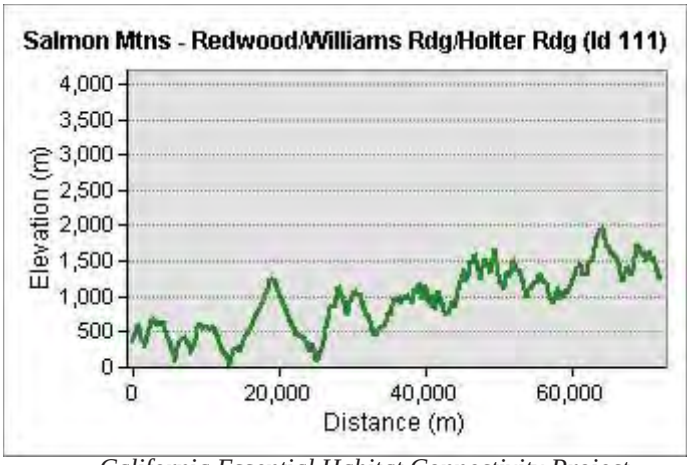

E Mesa Sand Dunes - Chocolate Mtns S (Id 106)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

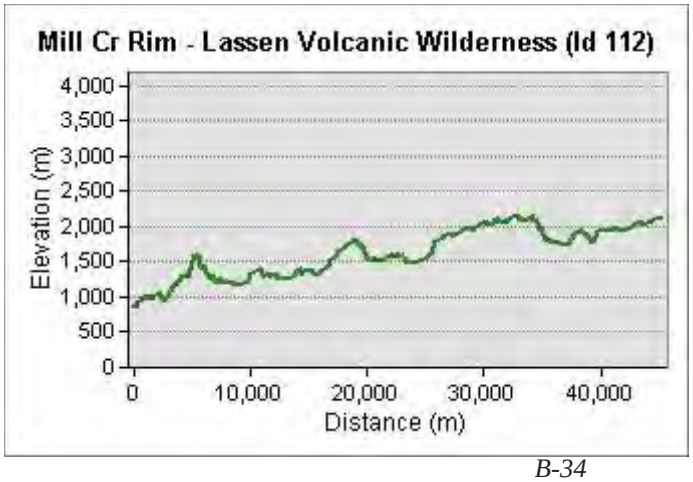

E Mesa Sand Dunes - Chocolate Mtns S (Id 107)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

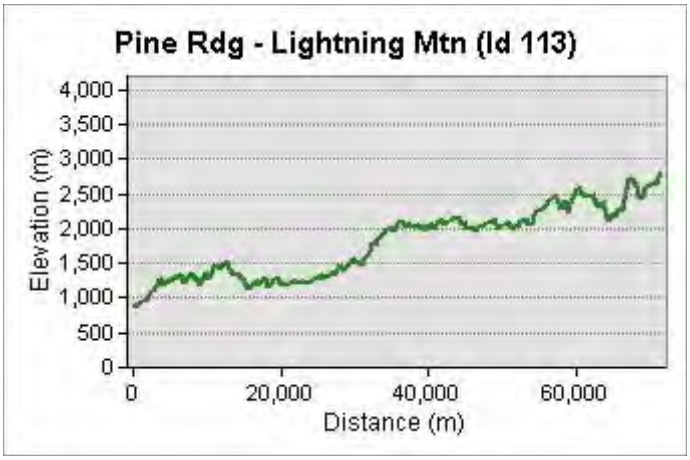

Jacumba Pk - Campo Valley (Id 108)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,00
Distance (m)

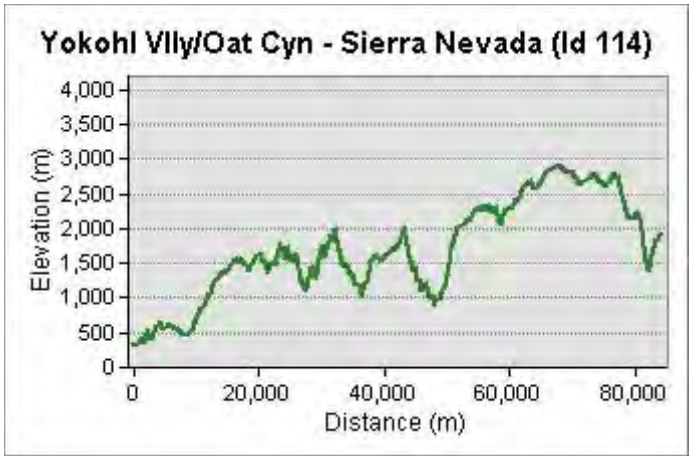

McGinty Mtn/Lawson Vlly - El Capitan (Id 109)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

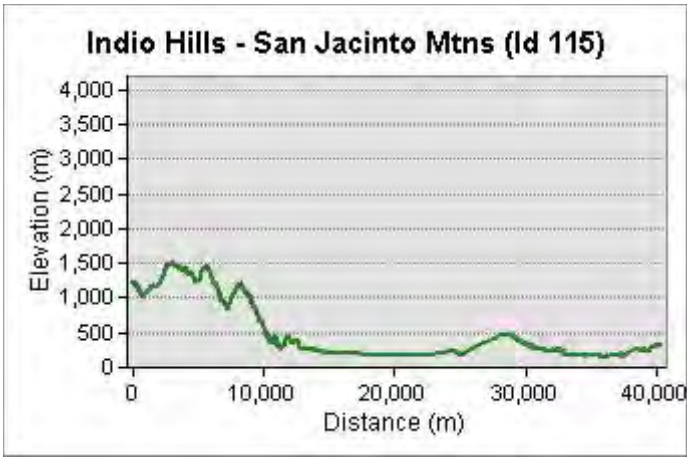

Noble Rdg/Beegum Gorge - S Fk Mtn/Chinquapin Butte (Id 110)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

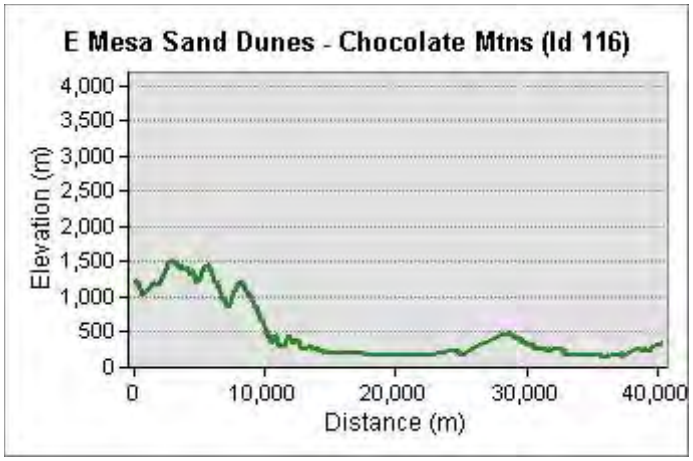

Salmon Mtns - Redwood/Williams Rdg/Holter Rdg (Id 111)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

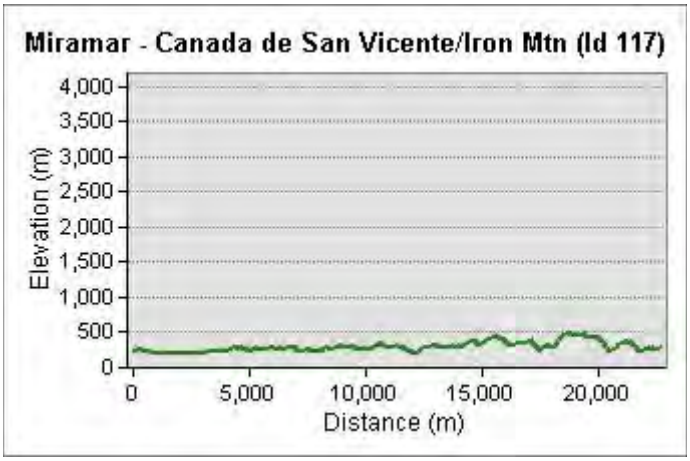

Mill Cr Rim - Lassen Volcanic Wilderness (Id 112)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

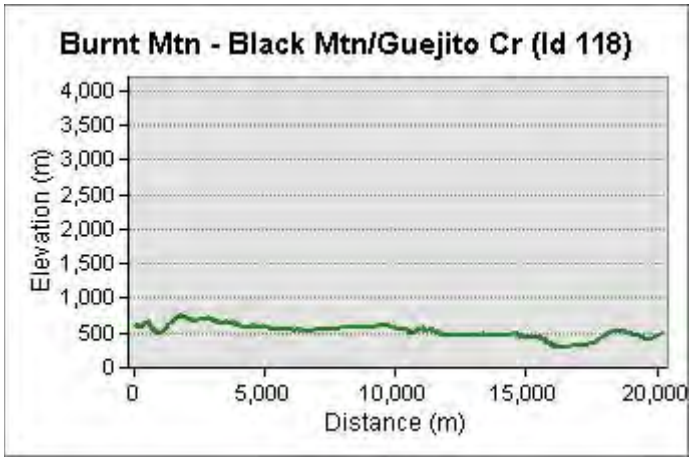

Pine Rdg - Lightning Mtn (Id 113)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

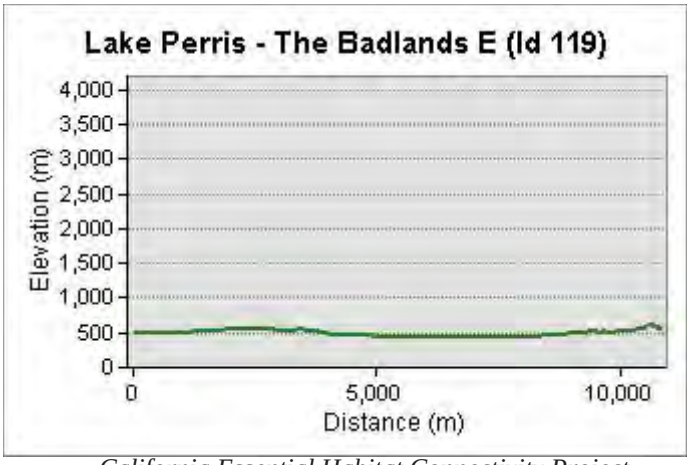

Yokohl Vlly/Oat Cyn - Sierra Nevada (Id 114)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

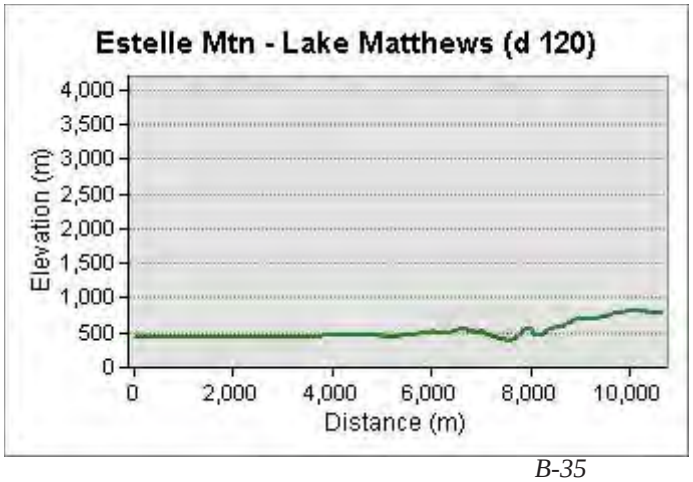

Indio Hills - San Jacinto Mtns (Id 115)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

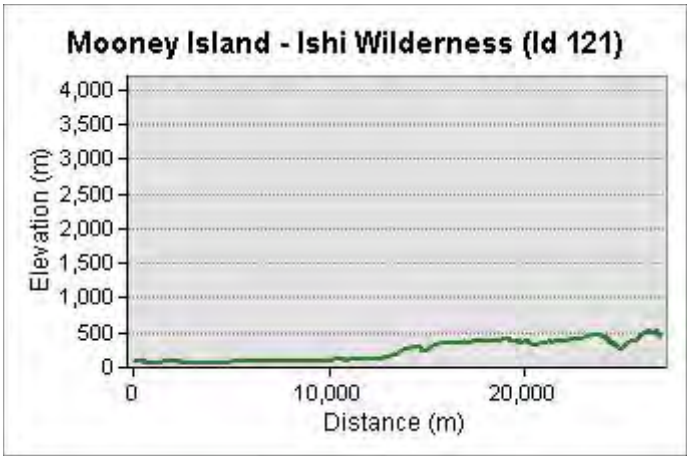

E Mesa Sand Dunes - Chocolate Mtns (Id 116)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

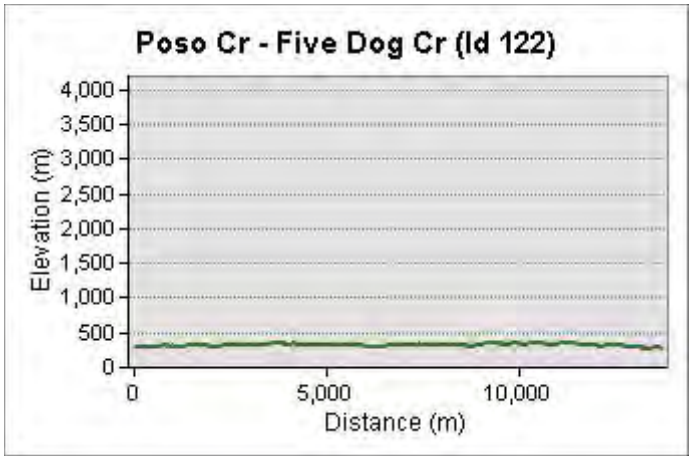

Miramar - Canada de San Vicente/Iron Mtn (Id 117)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

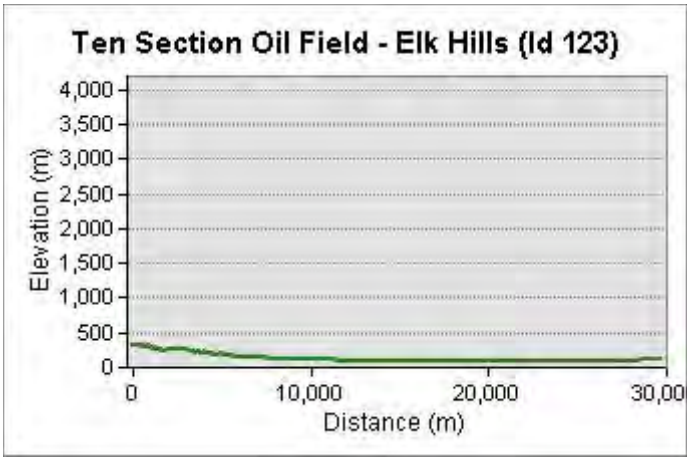

Burnt Mtn - Black Mtn/Guejito Cr (Id 118)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

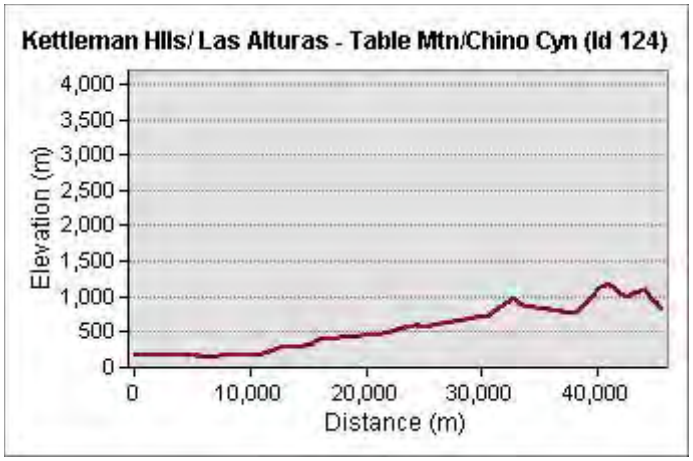

Lake Perris - The Badlands E (Id 119)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

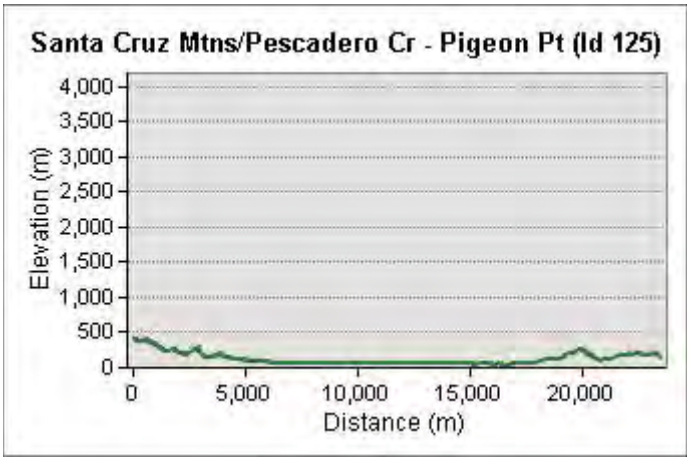

Estelle Mtn - Lake Matthews (d 120)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
2,000
4,000
6,000
8,000
10,000
Distance (m)

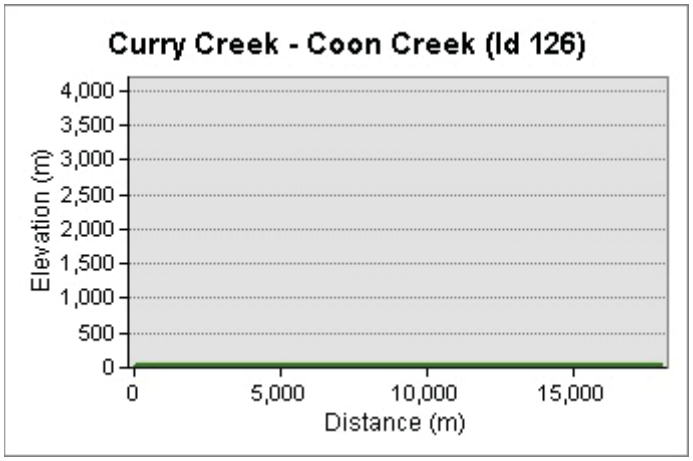

Mooney Island - Ishi Wilderness (Id 121)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

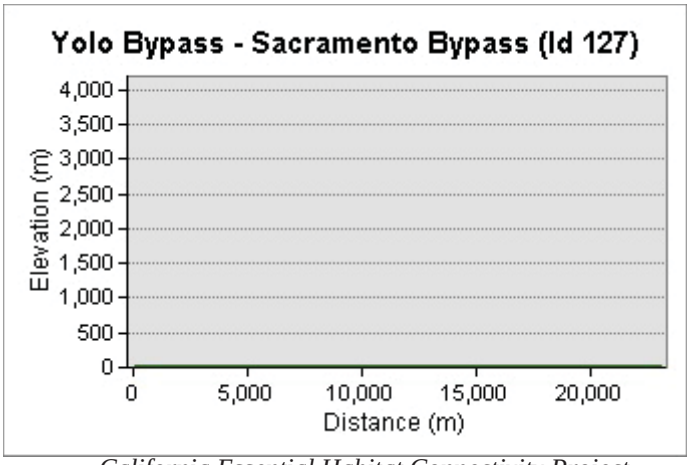

Poso Cr - Five Dog Cr (Id 122)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

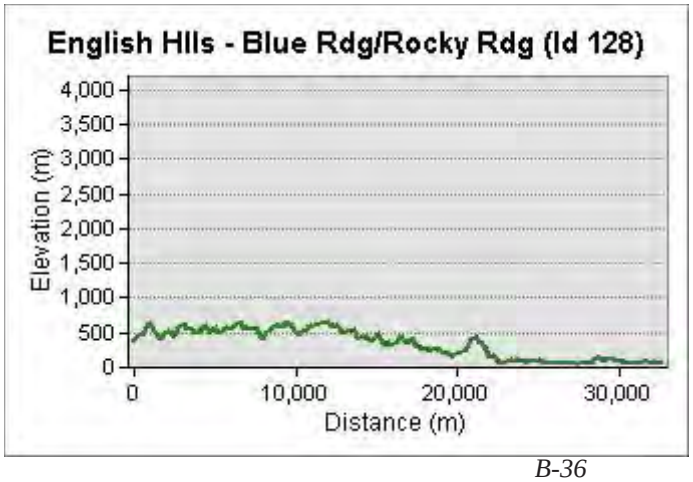

Ten Section Oil Field - Elk Hills (Id 123)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,00
Distance (m)

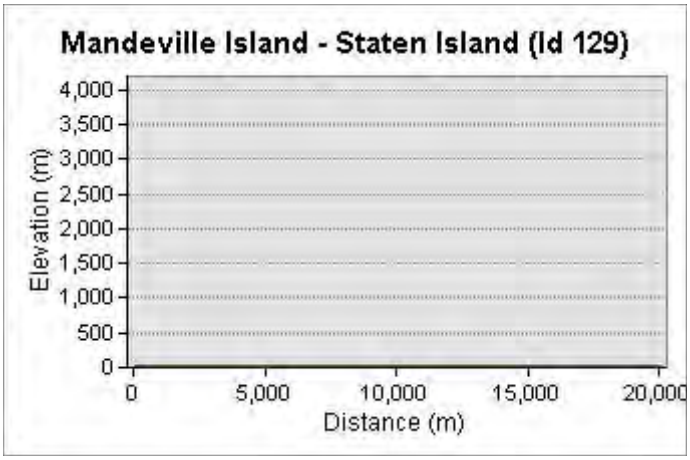

Kettleman Hlls/ Las Alturas - Table Mtn/Chino Cyn (Id 124)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

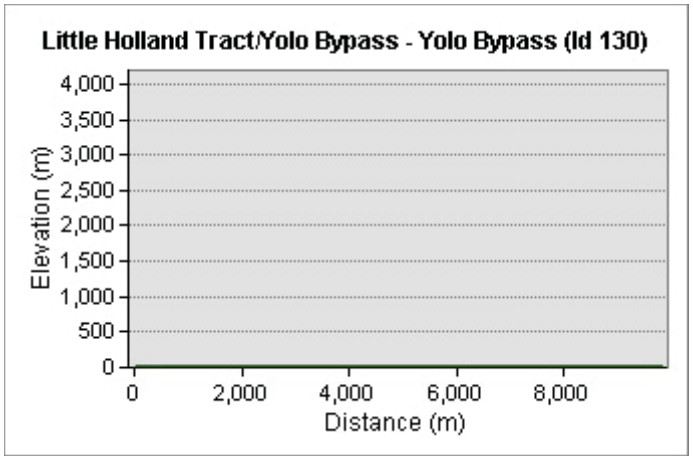

Santa Cruz Mtns/Pescadero Cr - Pigeon Pt (Id 125)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

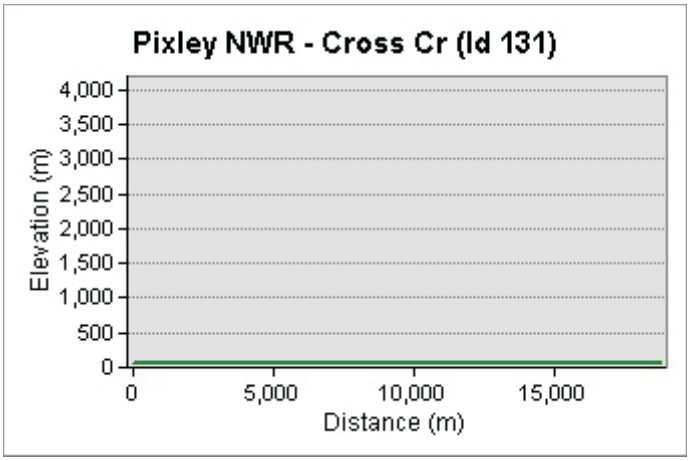

Curry Creek - Coon Creek (Id 126)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

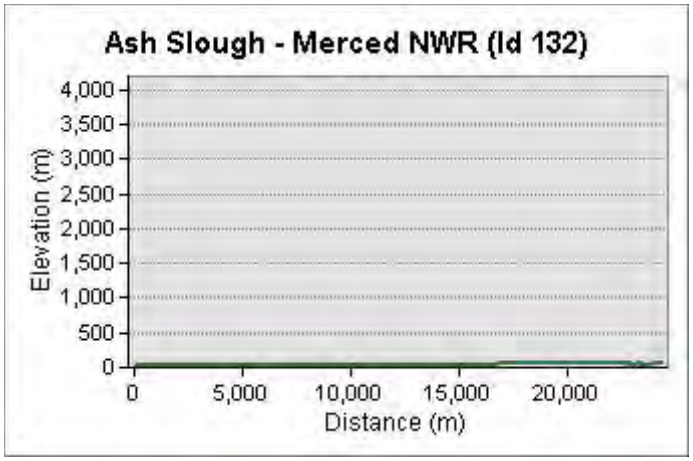

Yolo Bypass - Sacramento Bypass (Id 127)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

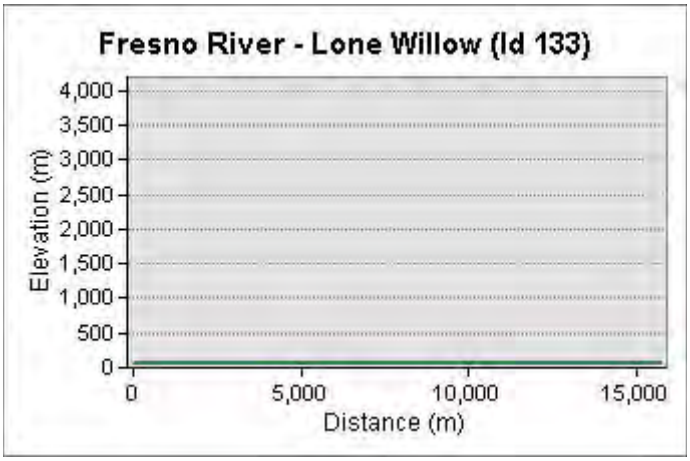

English Hlls - Blue Rdg/Rocky Rdg (Id 128)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

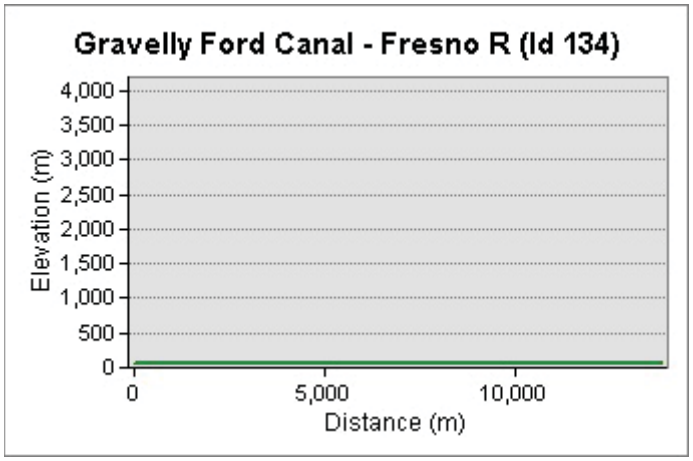

Mandeville Island - Staten Island (Id 129)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

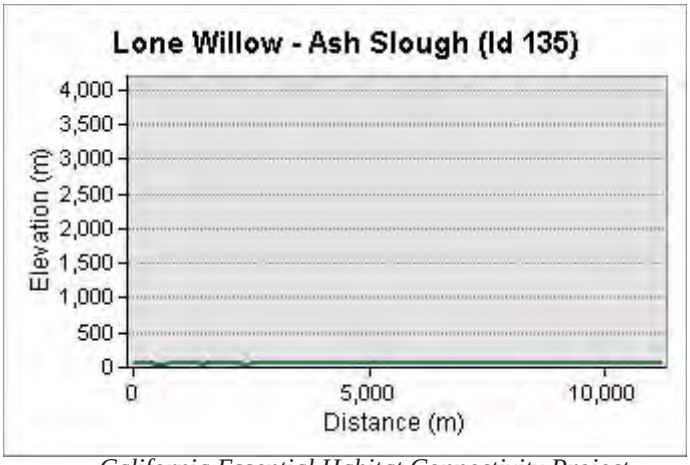

Little Holland Tract/Yolo Bypass - Yolo Bypass (Id 130)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
2,000
4,000
6,000
8,000
Distance (m)

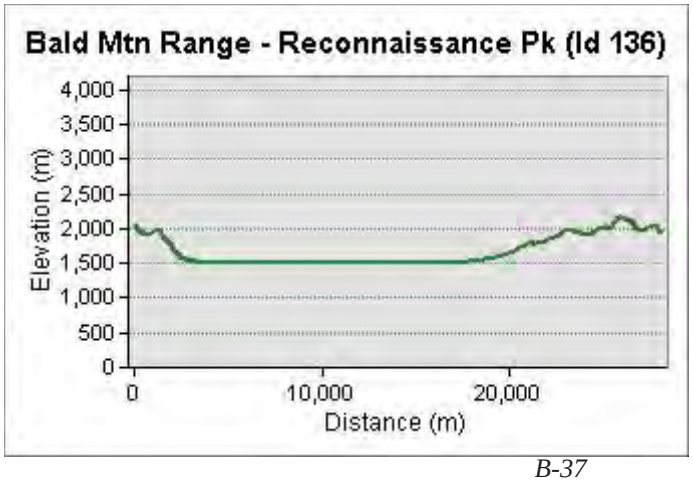

Pixley NWR - Cross Cr (Id 131)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

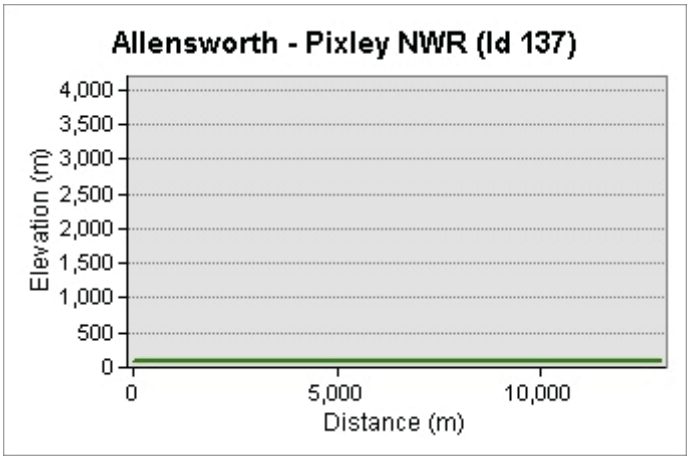

Ash Slough - Merced NWR (Id 132)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

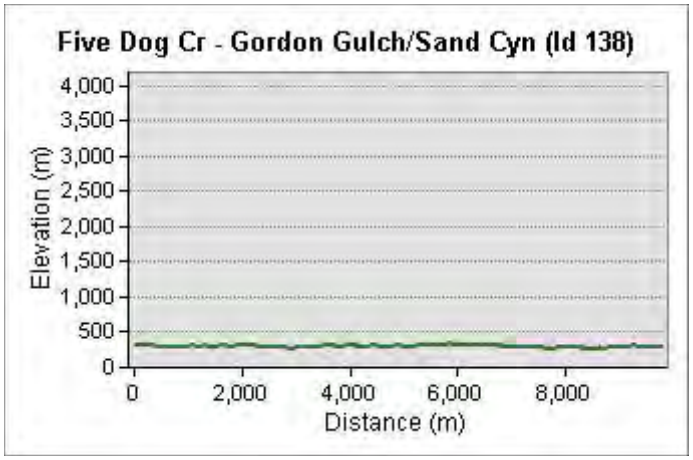

Fresno River - Lone Willow (Id 133)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

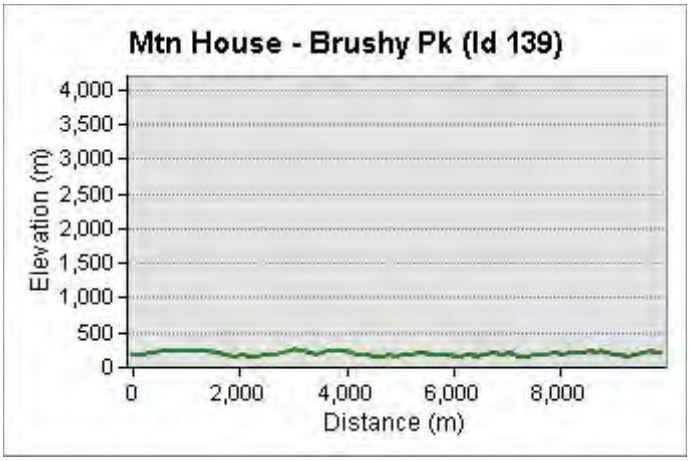

Gravelly Ford Canal - Fresno R (Id 134)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

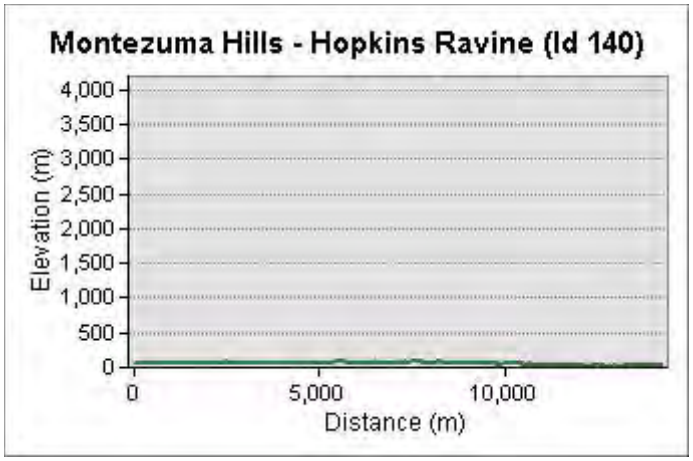

Lone Willow - Ash Slough (Id 135)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

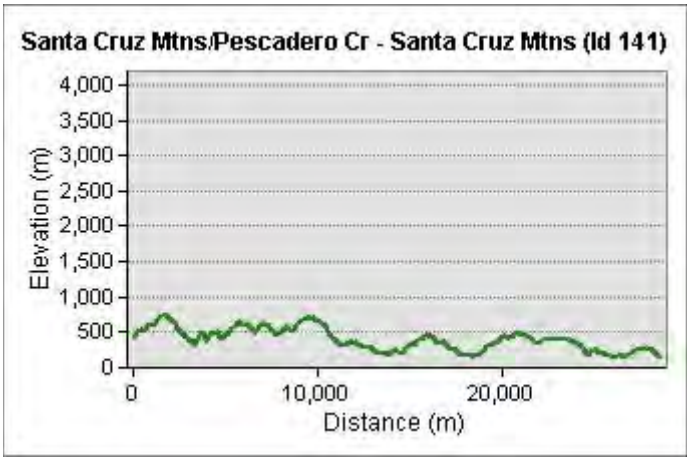

Bald Mtn Range - Reconnaissance Pk (Id 136)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

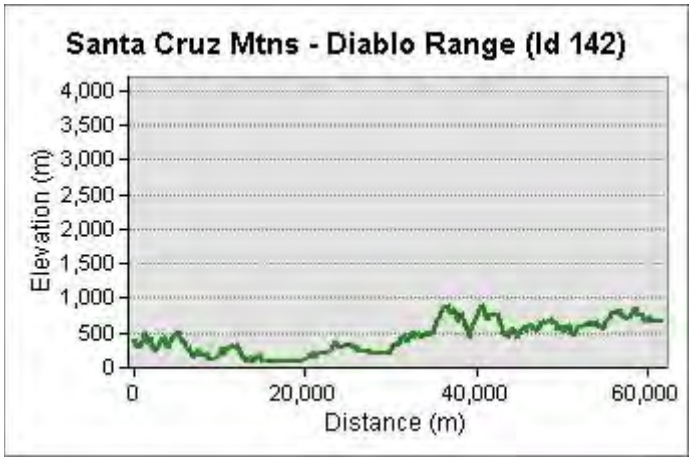

Allensworth - Pixley NWR (Id 137)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

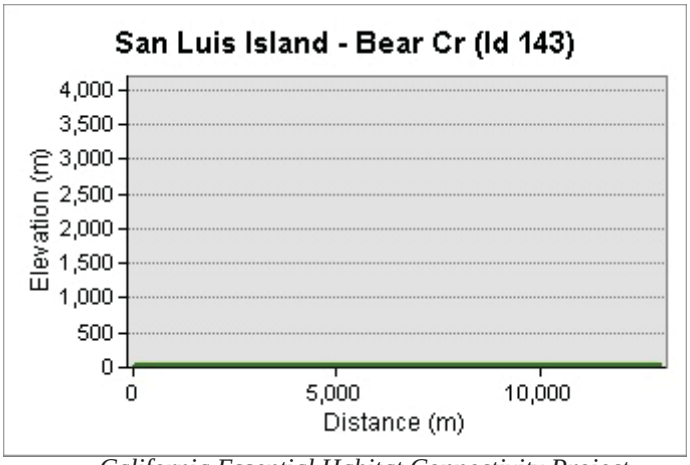

Five Dog Cr - Gordon Gulch/Sand Cyn (Id 138)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
2,000
4,000
6,000
8,000
Distance (m)

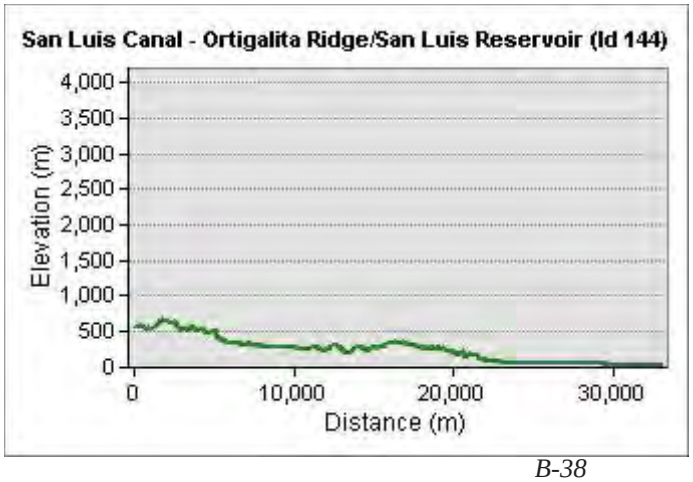

Mtn House - Brushy Pk (Id 139)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
2,000
4,000
6,000
8,000
Distance (m)


Montezuma Hills - Hopkins Ravine (Id 140)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

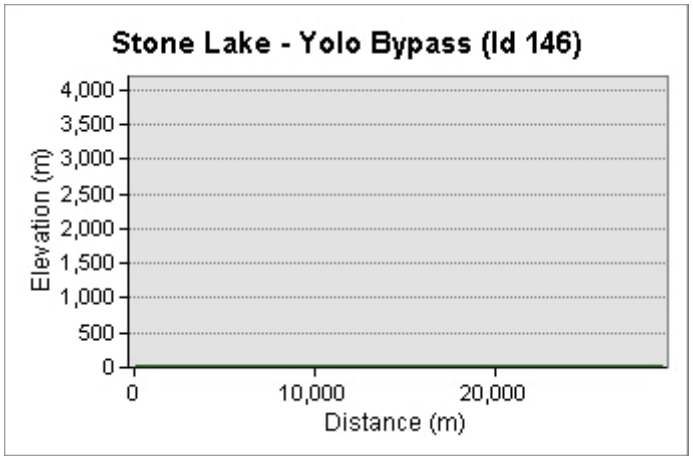

Santa Cruz Mtns/Pescadero Cr - Santa Cruz Mtns (Id 141)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

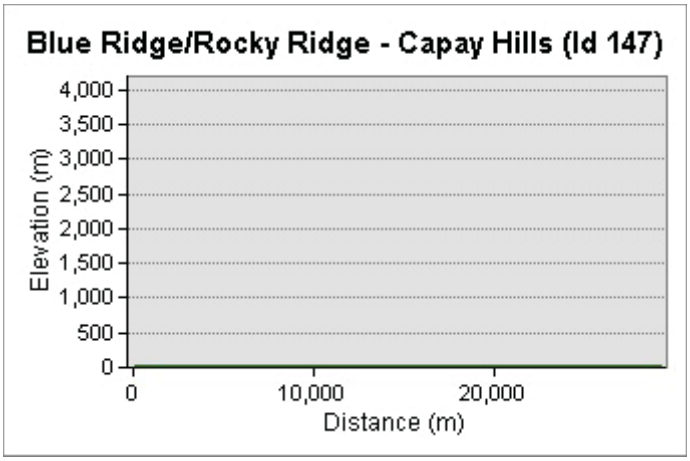

Santa Cruz Mtns - Diablo Range (Id 142)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

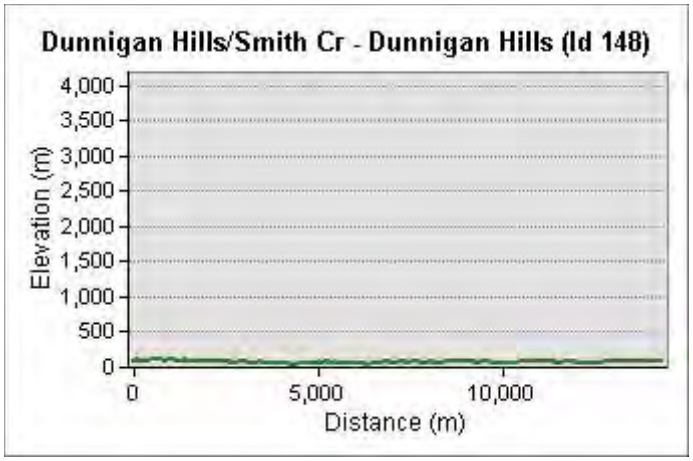

San Luis Island - Bear Cr (Id 143)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

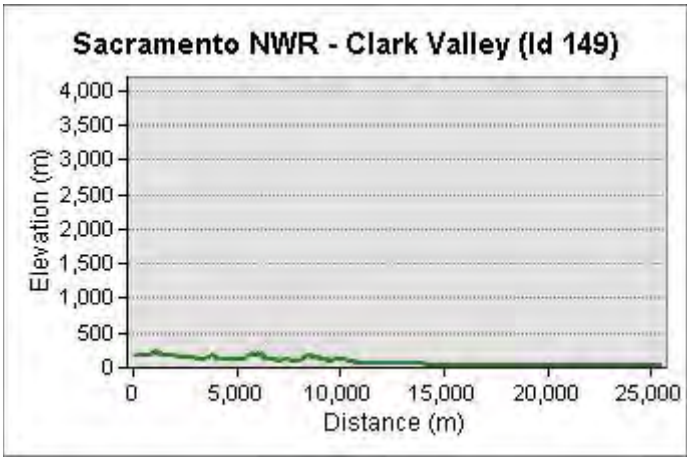

San Luis Canal - Ortigalita Ridge/San Luis Reservoir (Id 144)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

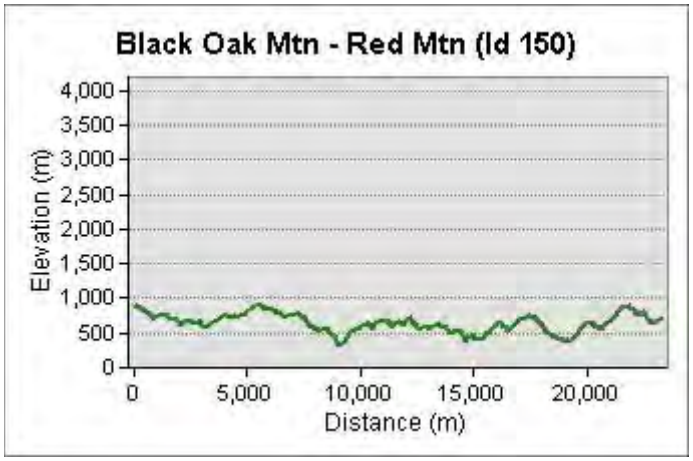
San Geronimo - Los Padres NF (Id 145)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

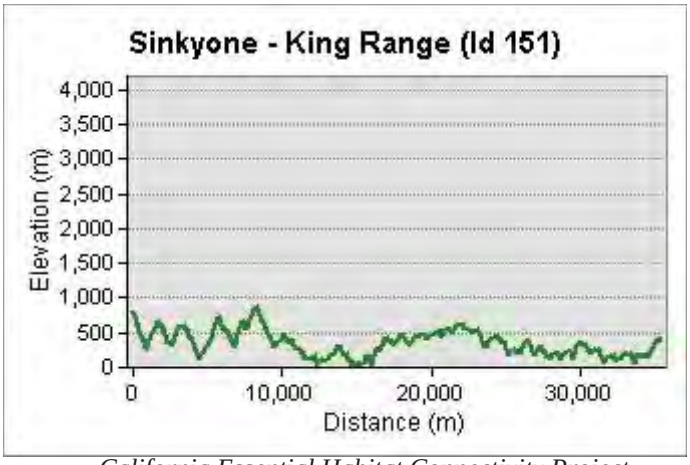

Stone Lake - Yolo Bypass (Id 146)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

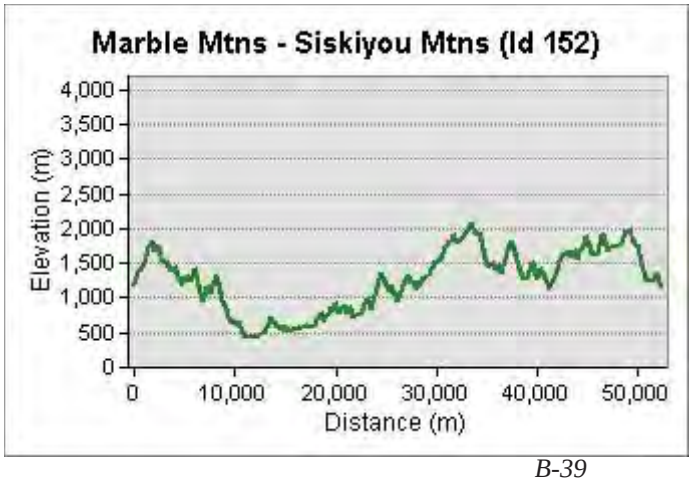

Blue Ridge/Rocky Ridge - Capay Hills (Id 147)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

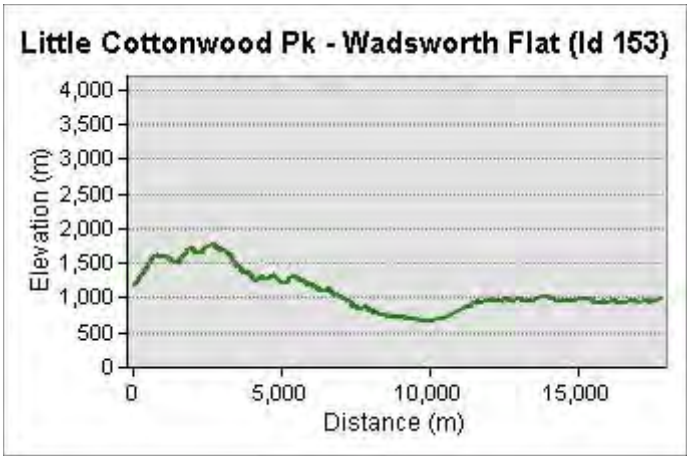

Dunnigan Hills/Smith Cr - Dunnigan Hills (Id 148)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
Distance (m)

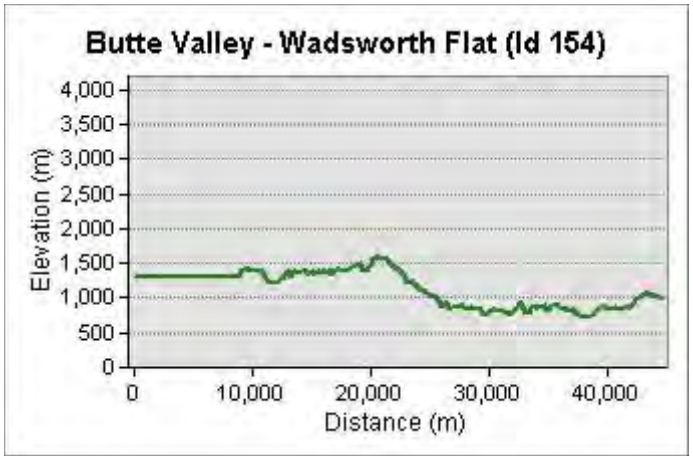

Sacramento NWR - Clark Valley (Id 149)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
25,000
Distance (m)

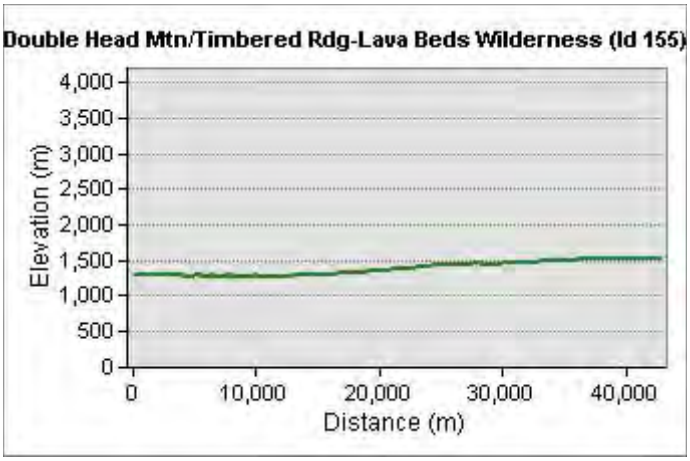

Black Oak Mtn - Red Mtn (Id 150)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

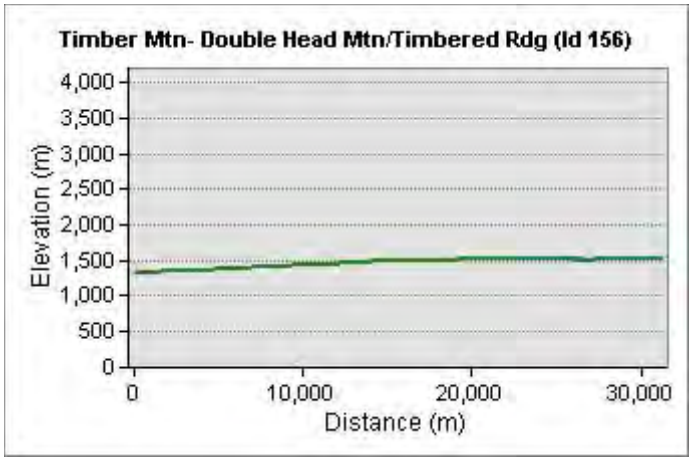

Sinkyone - King Range (Id 151)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

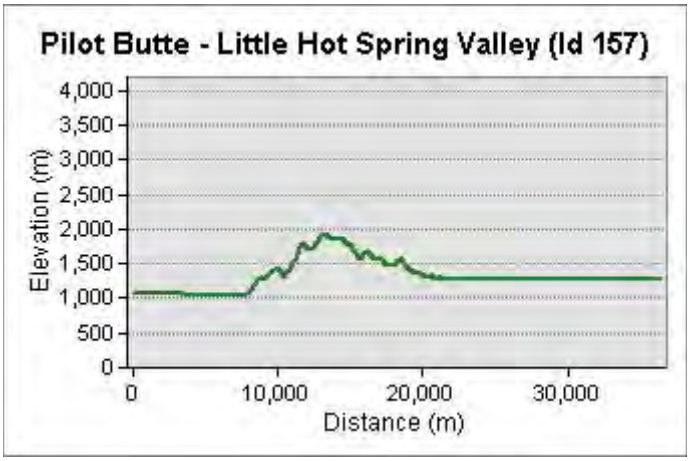

Marble Mtns - Siskiyou Mtns (Id 152)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
50,000
Distance (m)

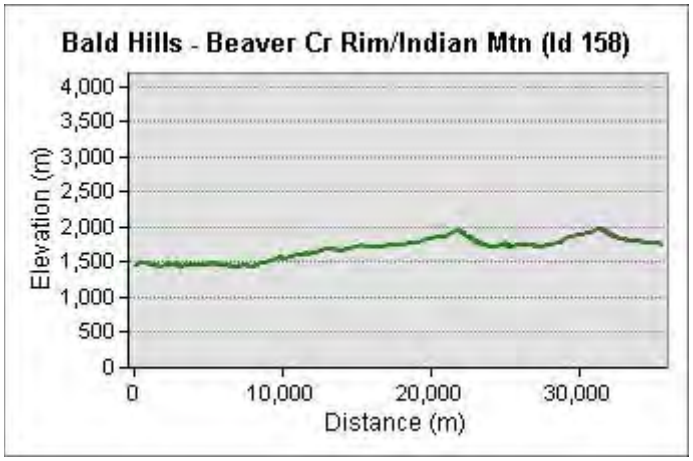

Little Cottonwood Pk - Wadsworth Flat (Id 153)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

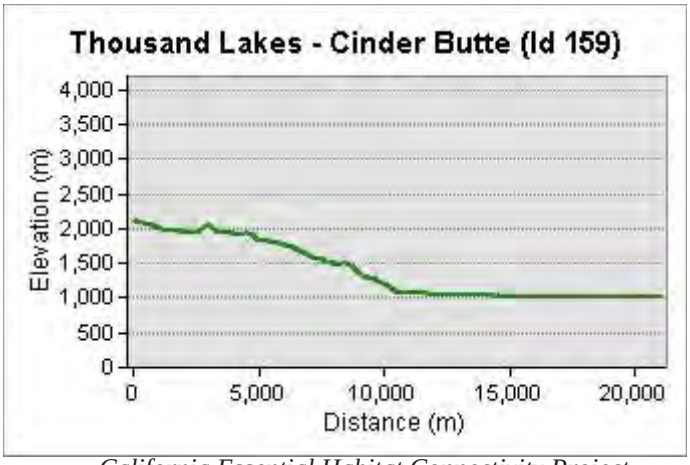

Butte Valley - Wadsworth Flat (Id 154)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

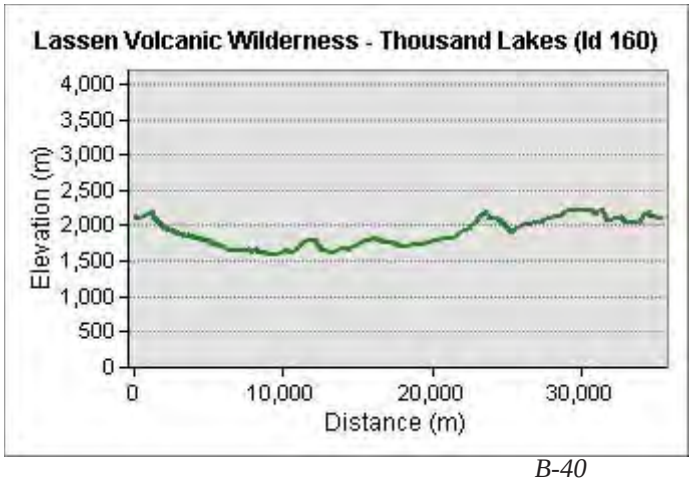

Double Head Mtn/Timbered Rdg-Lava Beds Wilderness (Id 155)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

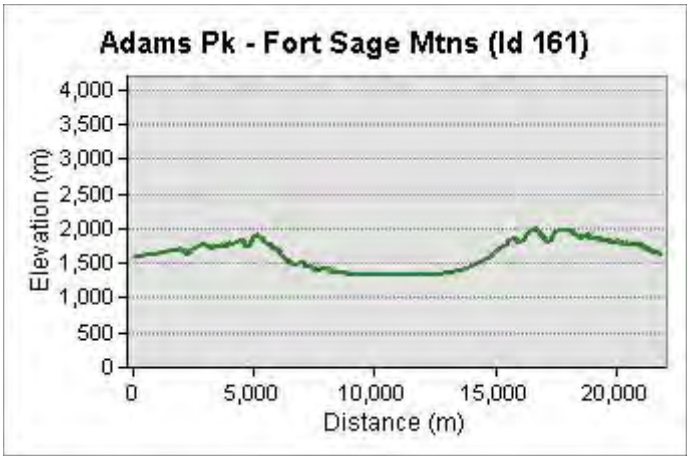

Timber Mtn- Double Head Mtn/Timbered Rdg (Id 156)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

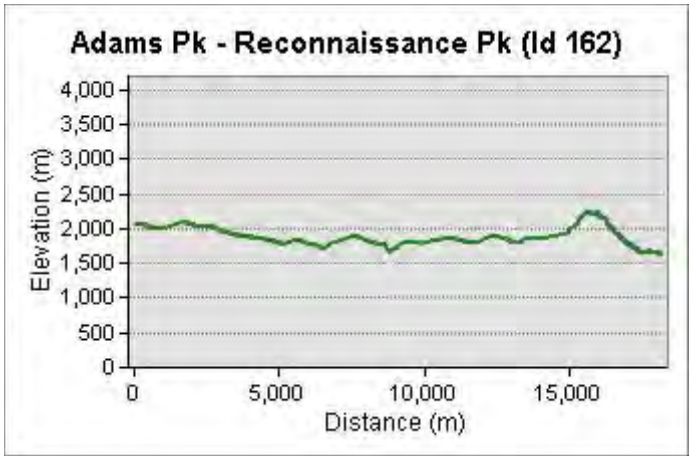

Pilot Butte - Little Hot Spring Valley (Id 157)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

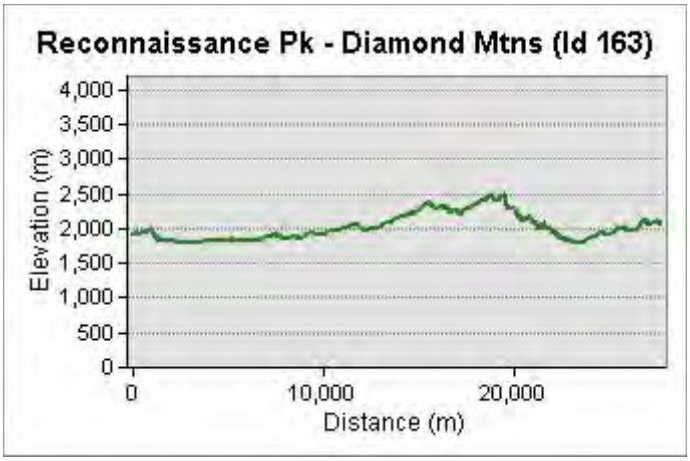

Bald Hills - Beaver Cr Rim/Indian Mtn (Id 158)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

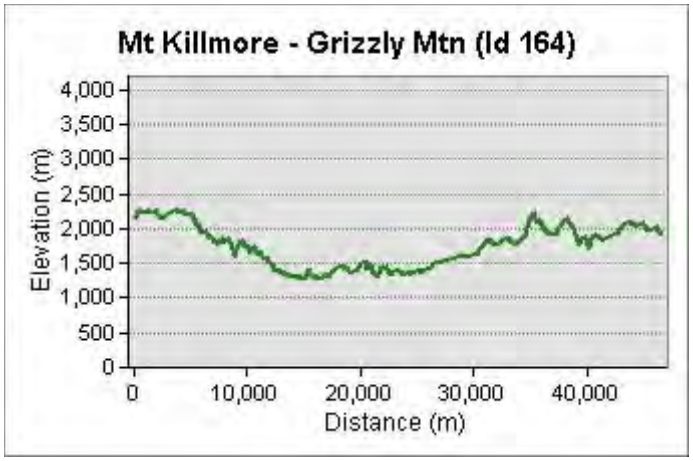

Thousand Lakes - Cinder Butte (Id 159)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

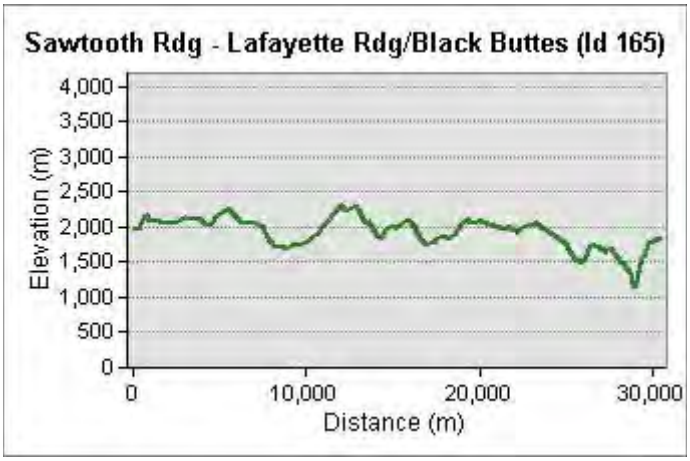

Lassen Volcanic Wilderness - Thousand Lakes (Id 160)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

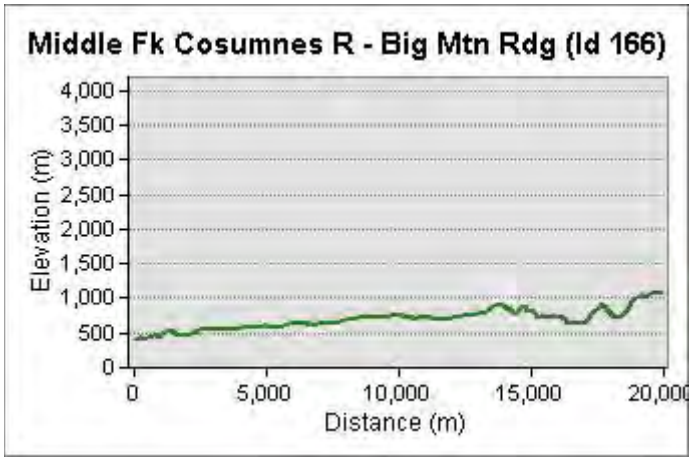

Adams Pk - Fort Sage Mtns (Id 161)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

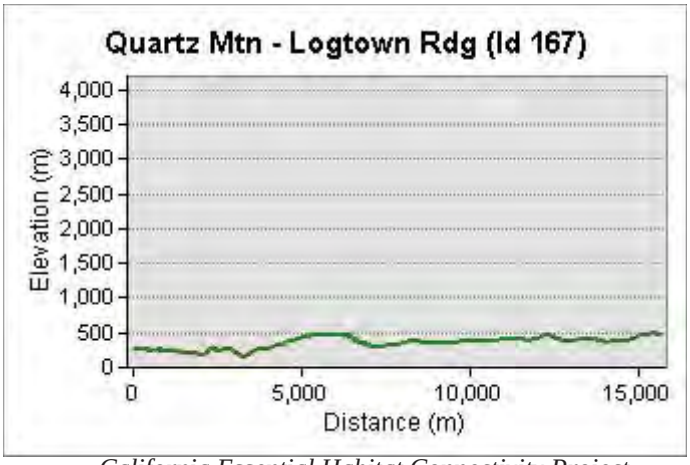

Adams Pk - Reconnaissance Pk (Id 162)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

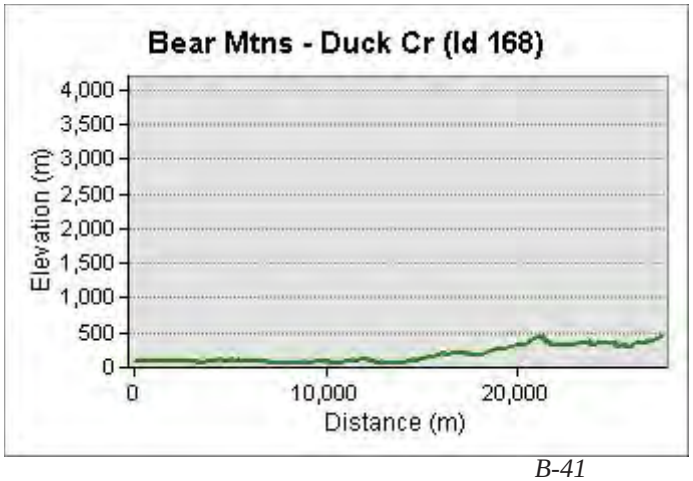

Reconnaissance Pk - Diamond Mtns (Id 163)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

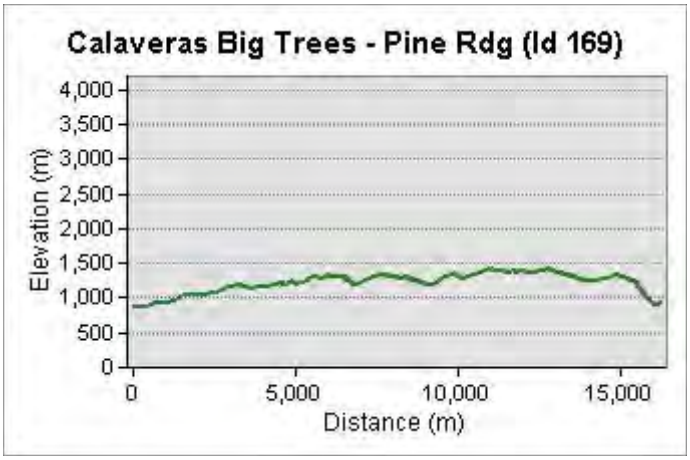

Mt Killmore - Grizzly Mtn (Id 164)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

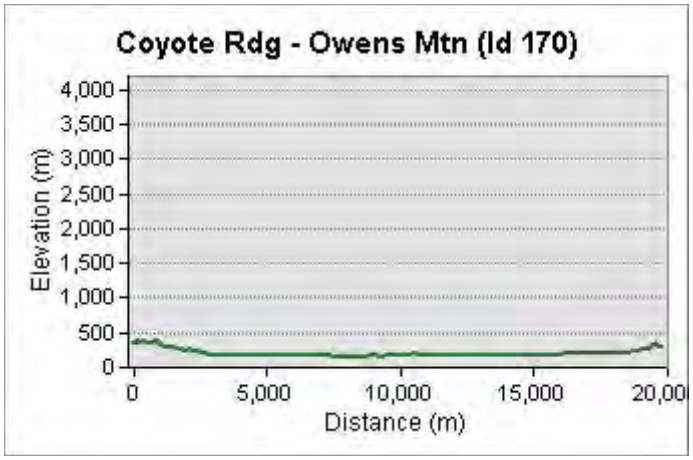

Sawtooth Rdg - Lafayette Rdg/Black Buttes (Id 165)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


Middle Fk Cosumnes R - Big Mtn Rdg (Id 166)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
Distance (m)

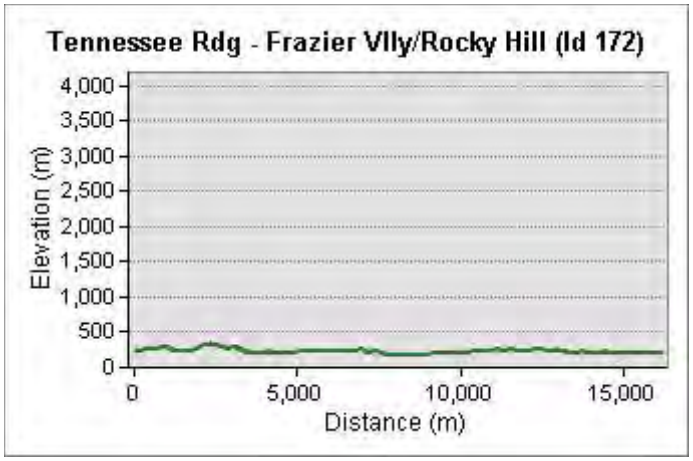

Quartz Mtn - Logtown Rdg (Id 167)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

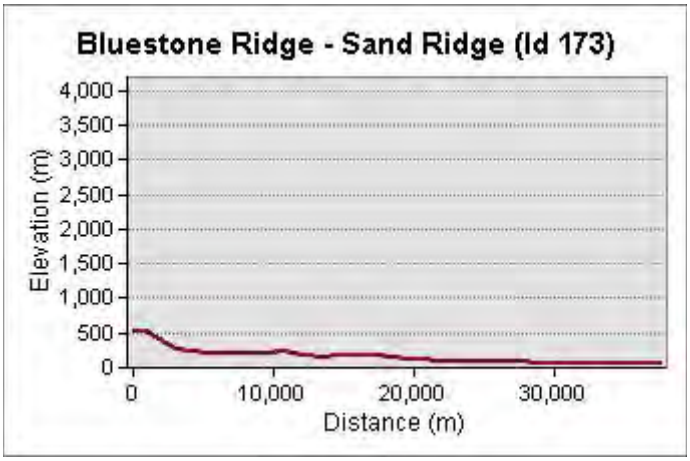

Bear Mtns - Duck Cr (Id 168)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

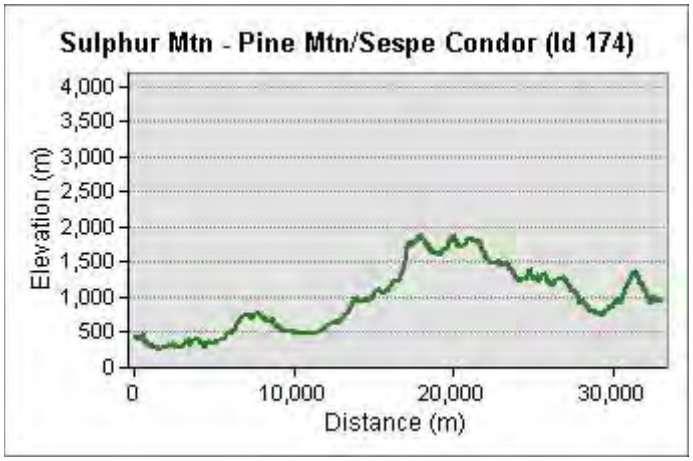

Calaveras Big Trees - Pine Rdg (Id 169)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

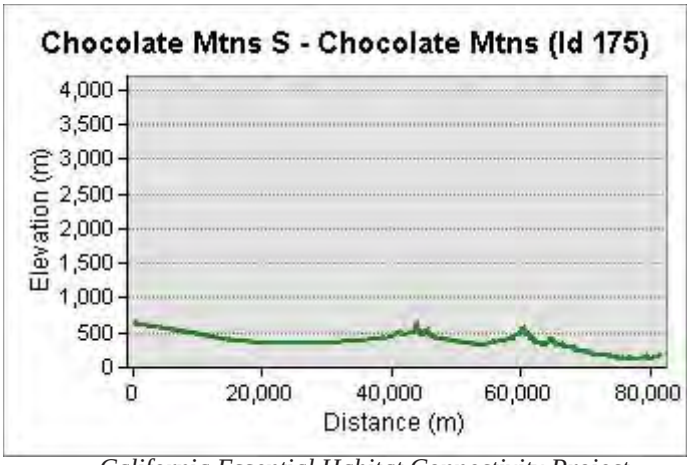

Coyote Rdg - Owens Mtn (Id 170)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,00
Distance (m)

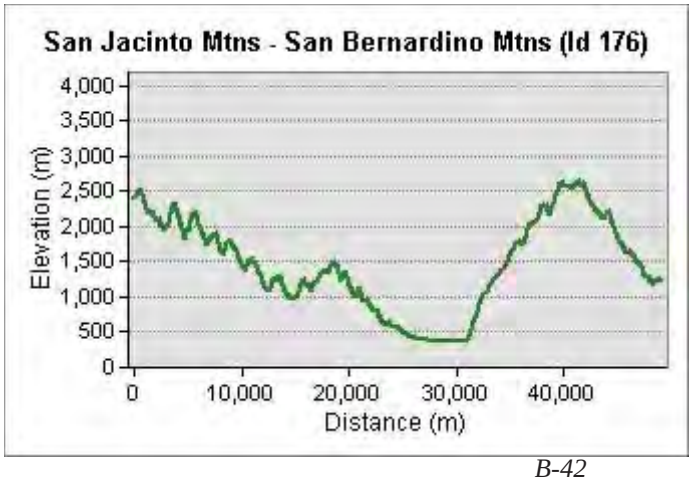
Coyote Rdg - Sierra Nevada (Id 171)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

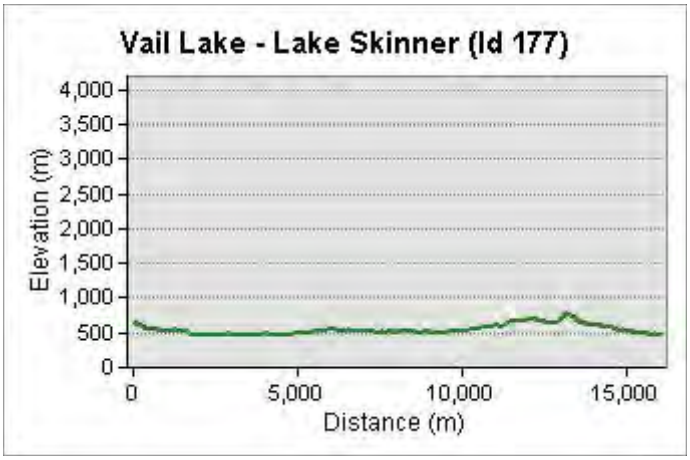

Tennessee Rdg - Frazier Vlly/Rocky Hill (Id 172)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

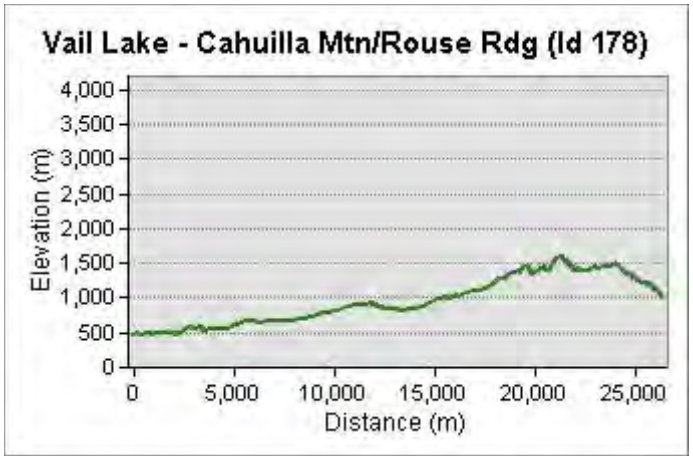

Bluestone Ridge - Sand Ridge (Id 173)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

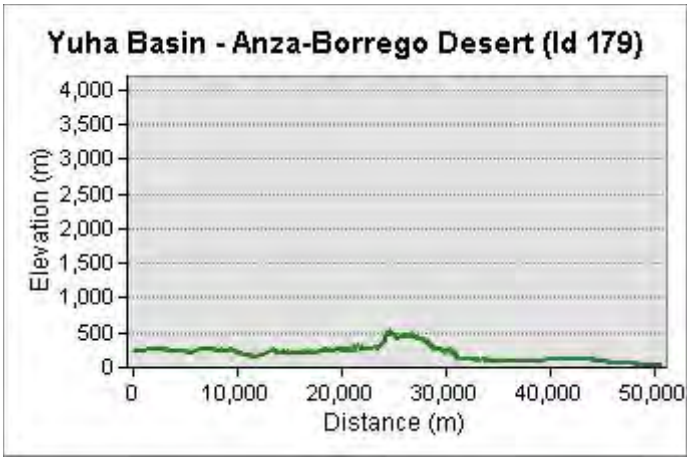

Sulphur Mtn - Pine Mtn/Sespe Condor (Id 174)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)

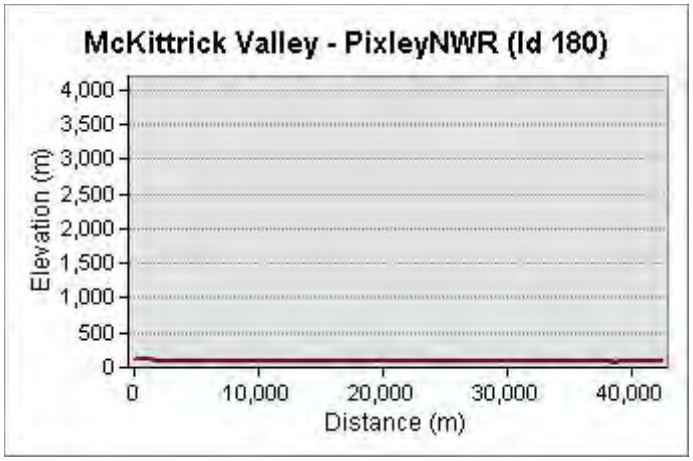

Chocolate Mtns S - Chocolate Mtns (Id 175)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

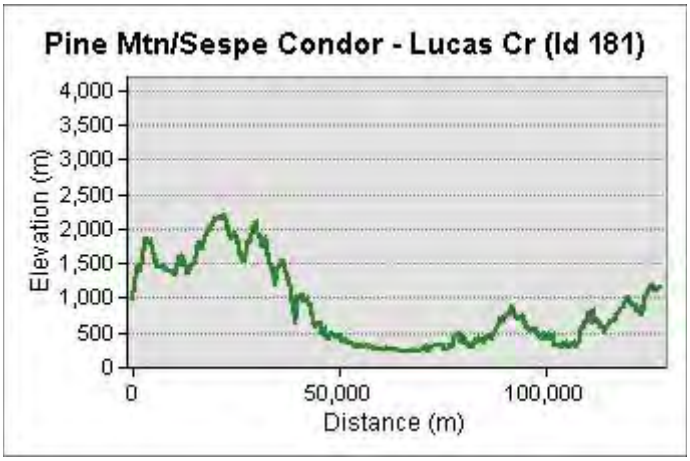

San Jacinto Mtns - San Bernardino Mtns (Id 176)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

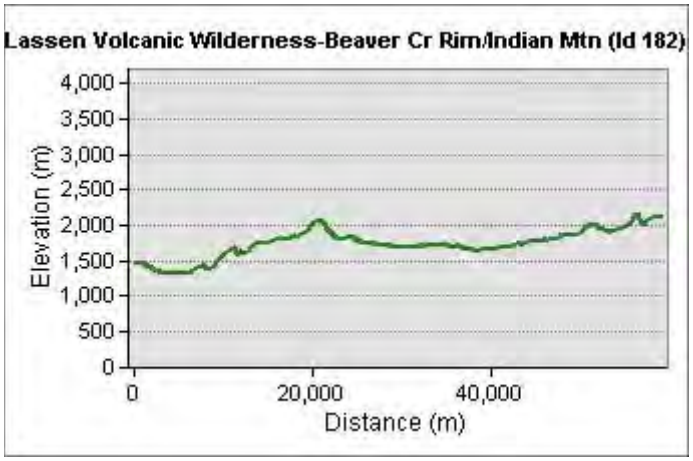

Vail Lake - Lake Skinner (Id 177)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
Distance (m)

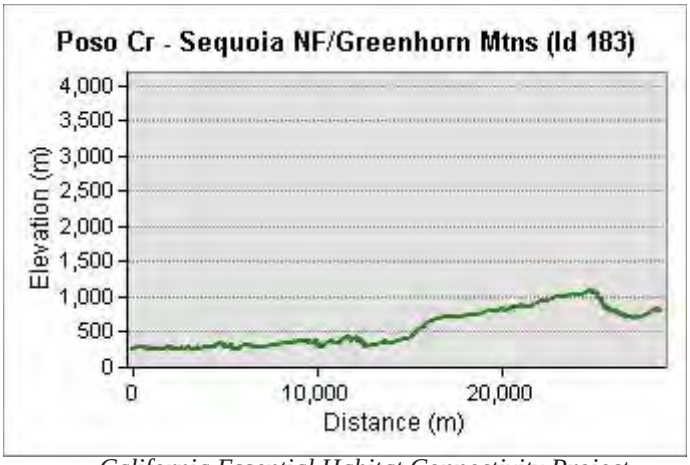

Vail Lake - Cahuilla Mtn/Rouse Rdg (Id 178)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
25,000
Distance (m)

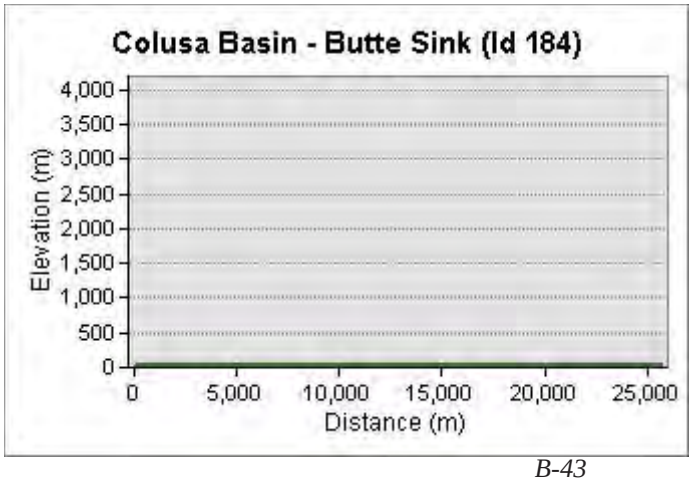

Yuha Basin - Anza-Borrego Desert (Id 179)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
50,000
Distance (m)

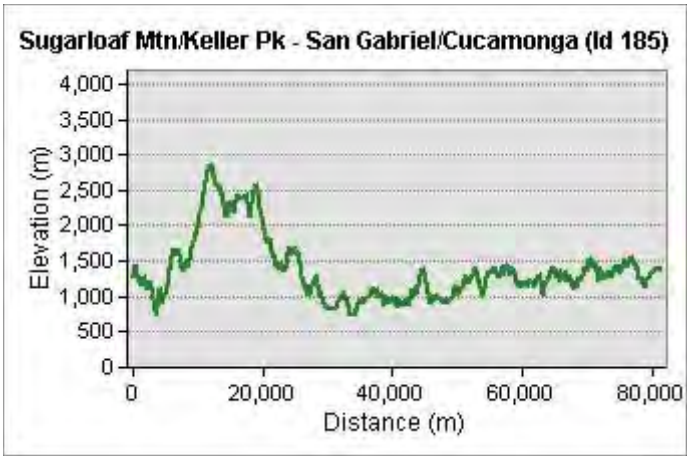

McKittrick Valley - PixleyNWR (Id 180)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

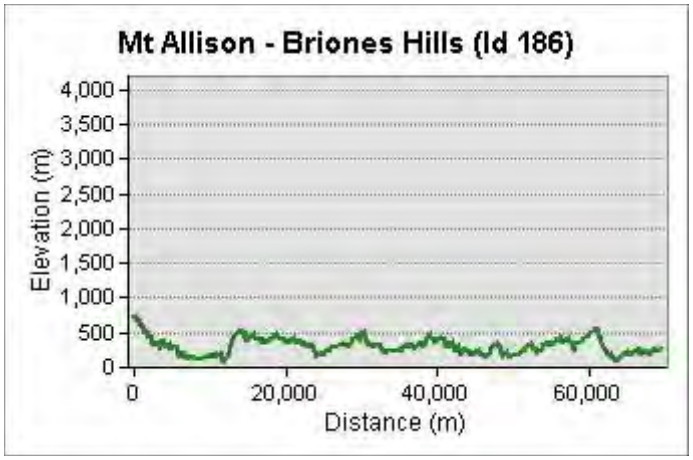

Pine Mtn/Sespe Condor - Lucas Cr (Id 181)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
50,000
100,000
Distance (m)

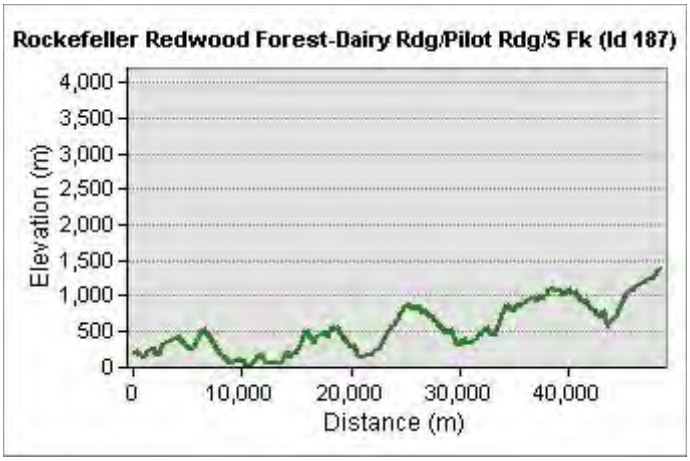

Lassen Volcanic Wilderness-Beaver Cr Rim/Indian Mtn (Id 182)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
Distance (m)

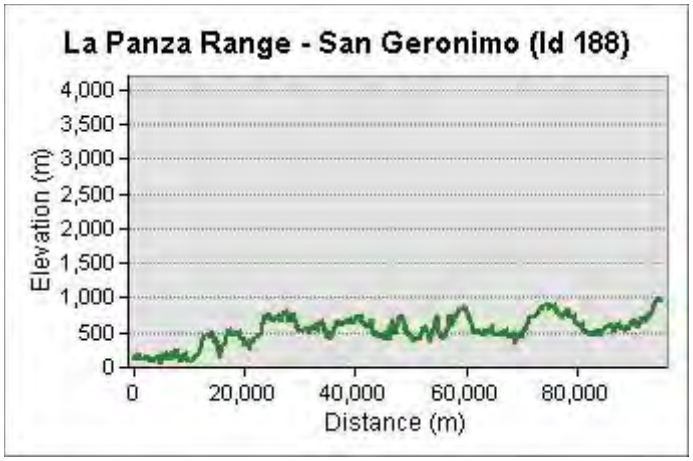

Poso Cr - Sequoia NF/Greenhorn Mtns (Id 183)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)

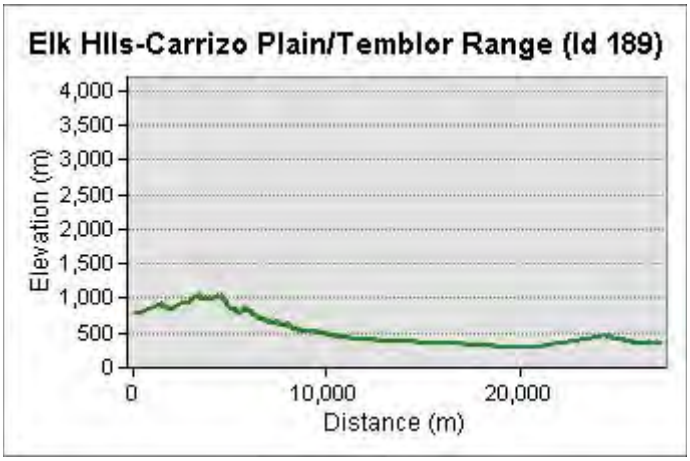

Colusa Basin - Butte Sink (Id 184)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
25,000
Distance (m)

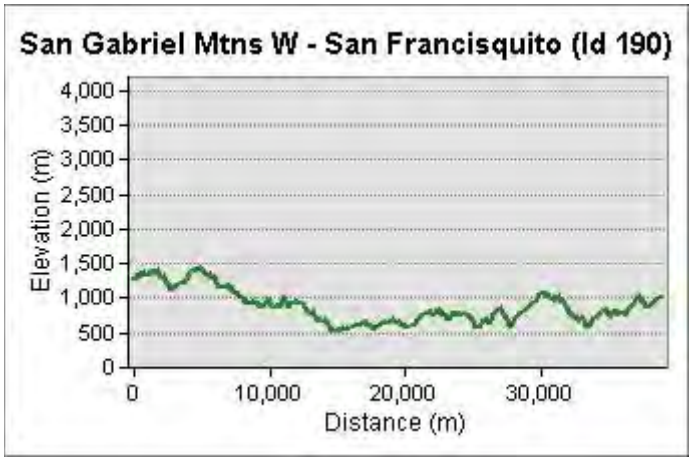

Sugarloaf Mtn/Keller Pk - San Gabriel/Cucamonga (Id 185)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

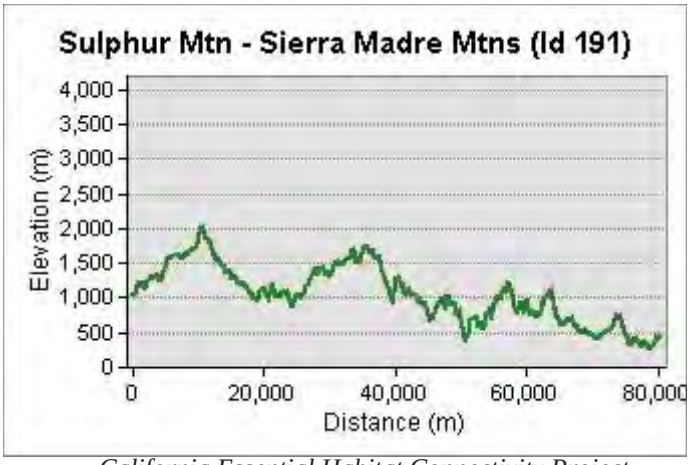

Mt Allison - Briones Hills (Id 186)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
Distance (m)

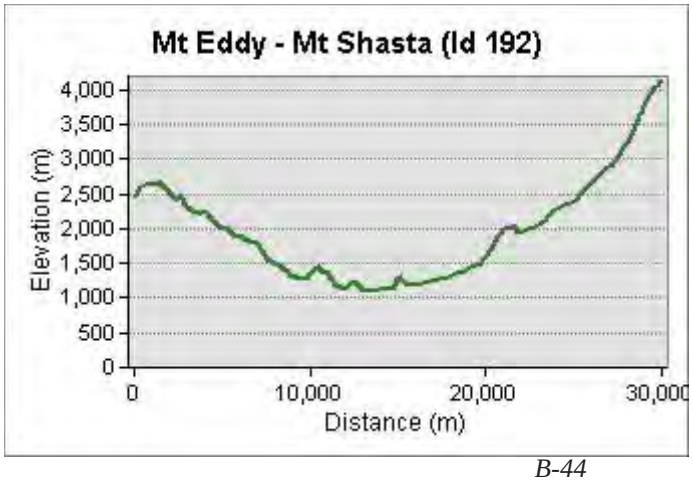

Rockefeller Redwood Forest-Dairy Rdg/Pilot Rdg/S Fk (Id 187)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
40,000
Distance (m)

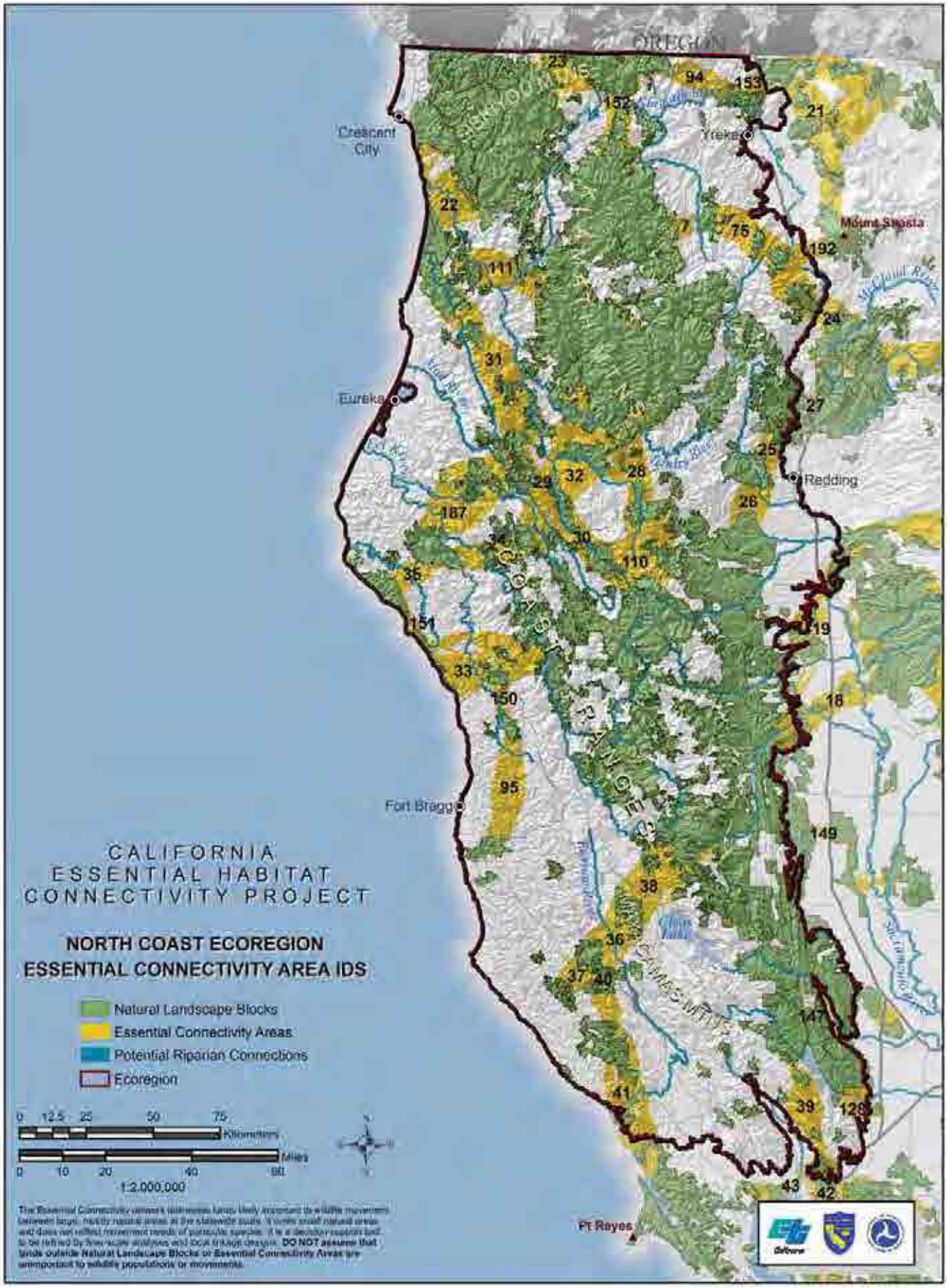

La Panza Range - San Geronimo (Id 188)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)

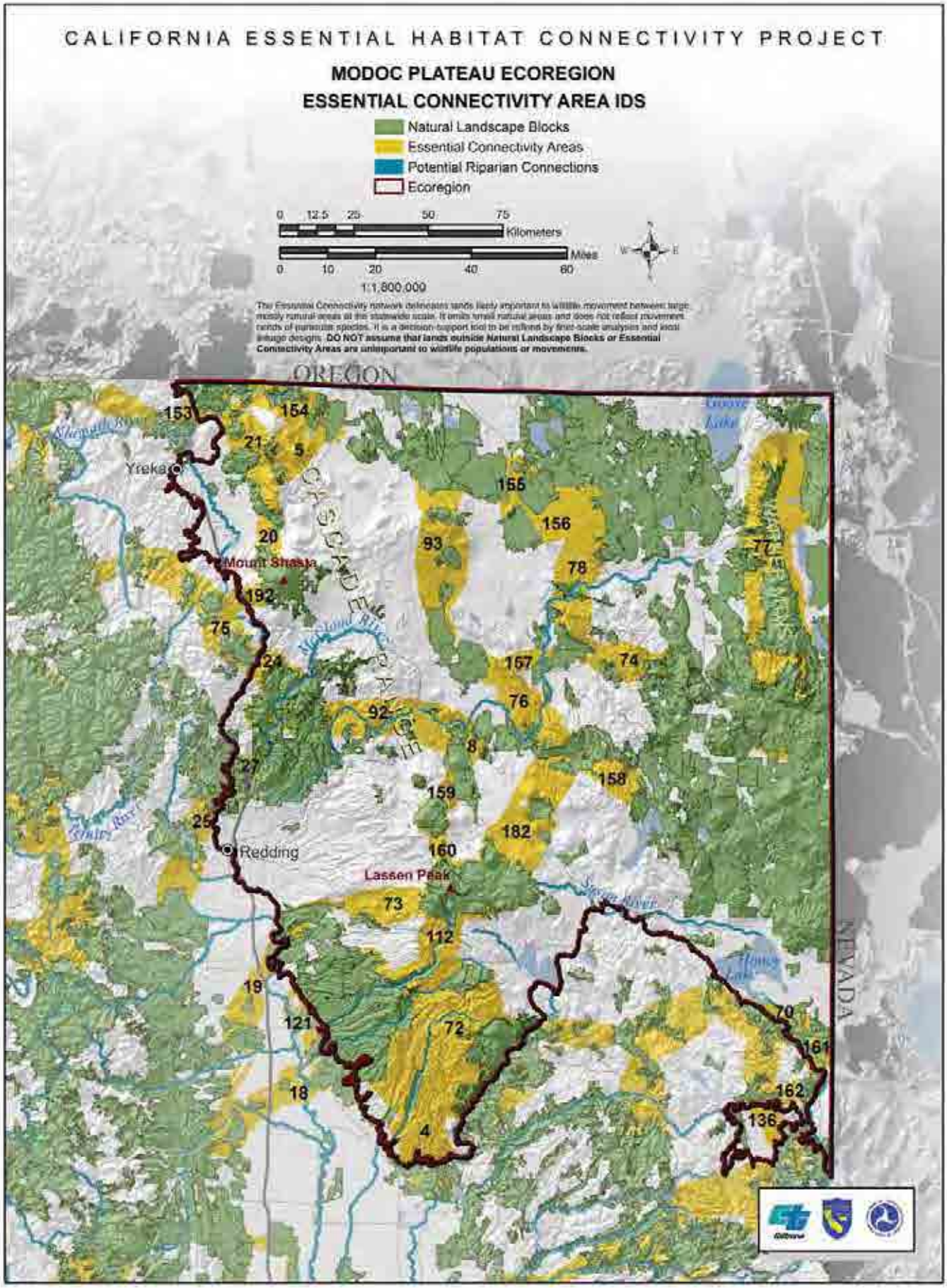

Elk Hills-Carrizo Plain/Temblor Range (Id 189)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
Distance (m)


San Gabriel Mtns W - San Francisquito (Id 190)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


Sulphur Mtn - Sierra Madre Mtns (Id 191)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
20,000
40,000
60,000
80,000
Distance (m)


Mt Eddy - Mt Shasta (Id 192)
Elevation (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10,000
20,000
30,000
Distance (m)


OREGON
Crescent City
Yreka
Mount Shasta
Eureka
Redding
Fort Bragg
Pt Reyes
CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
NORTH COAST ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 80
1:2,000,000
DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

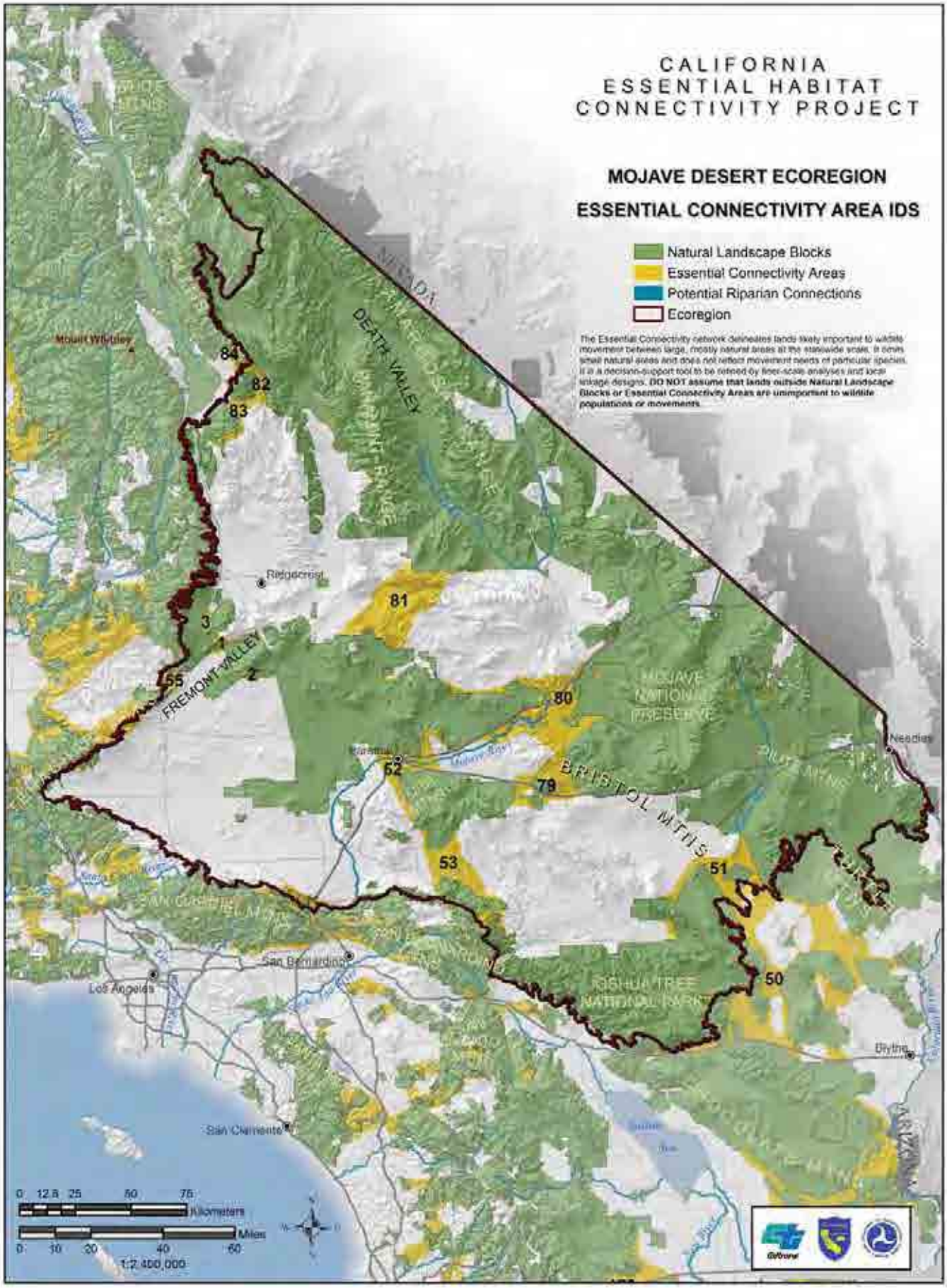

CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT
MODOC PLATEAU ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:1,800,000
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of numerous species. It is a decision-support tool to be refined by finer-scale analyses and local design. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
OREGON
NEVADA
Yreka
Mount Shasta
Redding
Lassen Peak
Shasta River
Klamath River
Sacramento River
Pit River
Goose Lake
Honey Lake
153
154
21
5
155
156
93
77
20
78
192
75
24
157
74
76
92
8
27
158
159
25
182
160
73
112
19
121
72
70
161
18
162
4
136

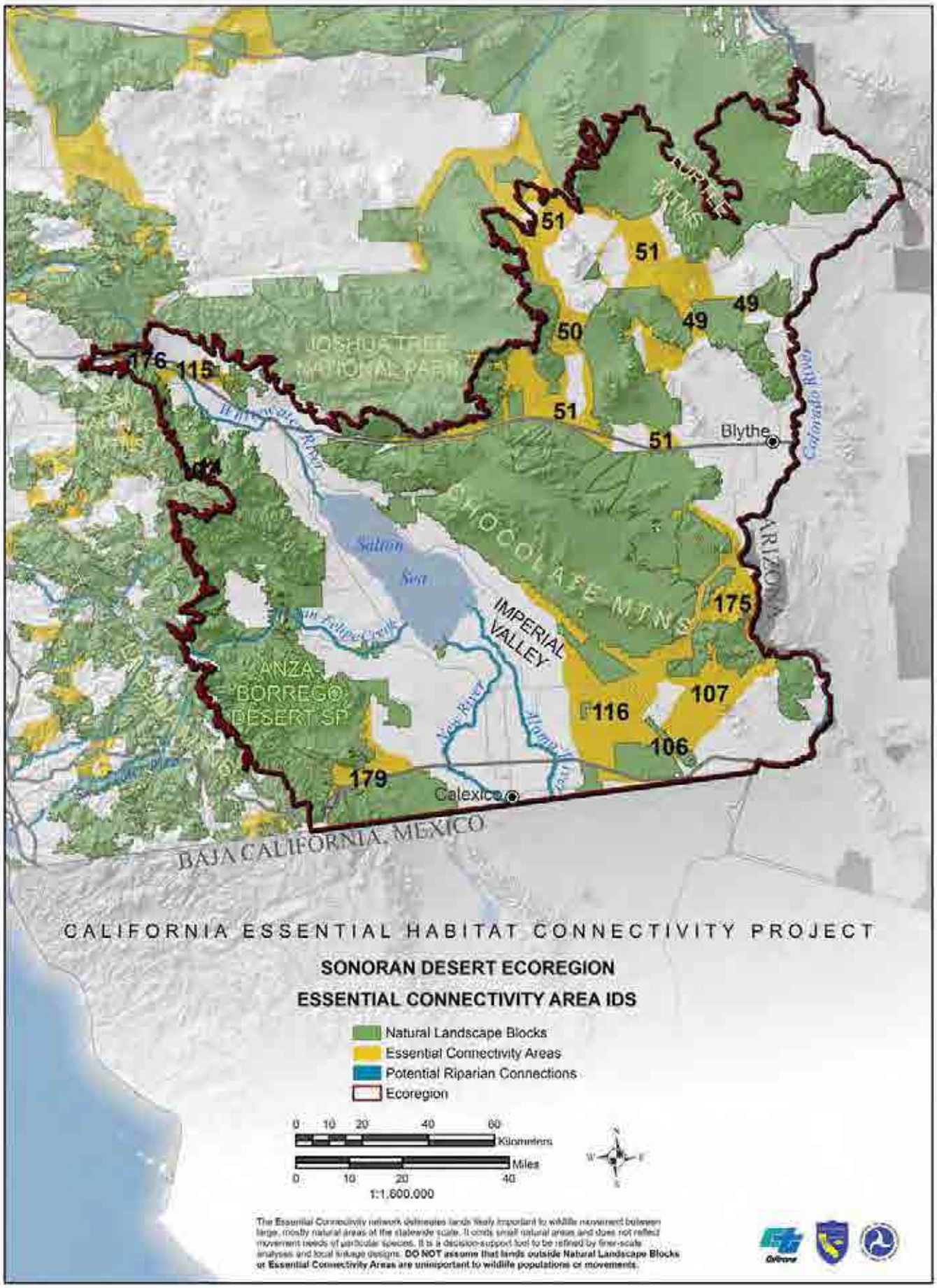
CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
CENTRAL COAST ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:2,500,000
Sacramento
Stockton
Pt Reyes
Mount Diablo
San Francisco
Monterey
Fresno
Tulare
Bakersfield
Santa Barbara
SAN JOAQUIN VALLEY
SALINAS VALLEY
COAST RANGES
39
41
43
42
188
45
96
44
142
141
125
15
144
97
46
48
47
86
124
173
145
188
189
98
191

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
CENTRAL VALLEY ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
SACRAMENTO VALLEY
SAN JOAQUIN VALLEY
COAST RANGE
SALINAS VALLEY
Redding
Lassen Park
Sacramento
Fresno
Tulare
Bakersfield
Monterey
Ridgecrest
The Essential Connectivity network delineates areas likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by fine-scale analysis and local design. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:3,000,000

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
SIERRA NEVADA ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision support tool to be refined by fine-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
SACRAMENTO VALLEY
SAN JOAQUIN VALLEY
SALINAS VALLEY
COAST RANGES
DEATH VALLEY
Sacramento
Stockton
Fresno
Tulare
Bakersfield
Tehachapi
0 12.5 25 50 75
Kilometers
0 10 20 40 60
Miles
1:3,000,000

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
SOUTH COAST ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 15 30 60 90 Kilometers
0 10 20 40 60 Miles
1:1,800,000
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
Barstow
Mojave River
Santa Barbara
San Bernardino
Los Angeles
San Clemente
San Diego
MEXICO
Los Angeles River
Santa Ana River
San Luis Rey River
Whitewater River
SAN GABRIEL MTNS
SAN BERNARDINO MTNS
SAN JACINTO MTNS
53
181
190
191
174
54
99
185
100
119
120
115
176
102
103
177
178
105
118
104
117
109
108


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
MOJAVE DESERT ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
DEATH VALLEY
Mount Whitney
Ridgecrest
FREMONT VALLEY
MOJAVE NATIONAL PRESERVE
Needles
BRISTOL MTNS
San Bernardino
Los Angeles
JOSHUA TREE NATIONAL PARK
Blythe
San Clemente
84
82
83
81
3
1
2
55
80
52
79
53
51
50
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:2,400,000


CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT
SONORAN DESERT ECOREGION
ESSENTIAL CONNECTIVITY AREA IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 10 20 40 60
Kilometers
Miles
0 10 20 40
1:1,600,000
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
51
51
49
49
50
176
115
51
51
Blythe
174
Salton Sea
CHOCOLATE MTNS
IMPERIAL VALLEY
175
ANZA BORREGO DESERT SP
107
116
106
179
Calexico
BAJA CALIFORNIA, MEXICO
ARIZONA
Colorado River

Characteristics of Natural Landscape Blocks

Identifier		Landform					ECI		Area		Protection Status				Species Diversity					Listed Species					Ecoregions	
ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
1	East Mesa/ All American Canal	20	11	30	4	19	80	33	4,831	20	99	92	7	1	206	25	0	2	0	0	0	0	0	2	1	SONORAN DESERT
2		14	8	26	4	18	67	42	5,516	22	98	97	1	2	215	22	0	1	0	0	0	0	0	1	1	SONORAN DESERT
3	East Mesa Sand Dunes	41	31	49	4	18	94	20	42,778	173	99	99	0	1	162	1	4	2	0	0	0	0	0	0	1	SONORAN DESERT
4	Jacumba Peak	960	827	1,159	67	332	72	17	3,576	14	15	13	2	85	241	13	8	5	0	95	1	0	0	0	1	SOUTH COAST
5	Rattlesnake Mountain	1,068	926	1,236	60	310	74	17	5,954	24	4	0	4	96	241	4	4	1	0	7	1	0	0	0	1	SOUTH COAST
6	Algodones Dunes	82	32	127	18	95	100	0	10,892	44	100	0	100	0	162	2	6	2	0	63	1	0	0	0	1	SONORAN DESERT
7	Campo Valley	991	801	1,133	86	332	79	19	8,172	33	36	0	36	64	248	1	6	2	0	0	0	29	1	0	1	SOUTH COAST
8		299	-1	1,226	257	1,227	92	21	54,857	222	99	97	2	1	197	17	12	9	0	65	1	0	0	0	1	SONORAN DESERT
9	Yuha Basin	55	-7	160	40	167	89	26	45,984	186	100	100	0	0	189	23	7	4	0	2	1	0	0	0	1	SONORAN DESERT
10	Tijuana River	17	1	130	30	129	NoData	NoData	2,937	12	99	99	0	1	292	18	26	26	100	12	2	0	1	42	1	SOUTH COAST
11	Clover Flat	1,048	866	1,261	89	395	78	17	7,805	32	23	3	20	77	248	1	3	1	0	0	0	28	1	1	1	SOUTH COAST
12		16	8	30	5	22	100	0	2,540	10	98	94	4	2	173	2	0	1	0	0	0	0	0	0	1	SONORAN DESERT
13	La Posta	1,023	865	1,168	69	303	79	21	5,621	23	74	7	66	26	249	1	1	0	0	0	0	41	2	0	1	SOUTH COAST
14	San Ysidro Mountains	439	61	1,072	215	1,011	78	17	34,202	138	87	78	9	13	273	5	45	28	56	72	7	34	6	1	1	SOUTH COAST
15	Gold Basin Rand Mine	205	163	280	19	117	94	19	8,653	35	92	21	71	8	162	2	1	1	0	84	1	0	0	0	1	SONORAN DESERT
16	San Miguel/Jamul Mountains	286	60	778	110	718	46	35	22,642	92	97	96	0	3	273	5	37	33	100	90	5	26	5	1	1	SOUTH COAST
17	Hauser Mountain	868	231	1,479	232	1,248	85	22	100,968	409	75	29	45	25	252	5	27	22	0	0	0	10	3	0	1	SOUTH COAST
18	Chocolate Mountains South	243	54	656	98	602	97	12	102,366	414	99	84	15	1	223	28	3	19	18	15	2	1	1	0	1	SONORAN DESERT
19	McGinty Mountain/Lawson Valley	576	112	1,155	235	1,043	58	36	23,823	96	72	42	30	28	263	11	18	24	35	8	2	84	3	0	1	SOUTH COAST
20	Guatay Mountain	1,251	1,047	1,482	81	435	50	41	3,156	13	79	41	38	21	255	2	9	1	0	0	0	2	1	0	1	SOUTH COAST
21	Sweetwater River/Peterson Canyon	785	416	1,131	148	715	80	27	12,176	49	53	3	50	47	255	2	5	8	0	0	0	89	2	0	1	SOUTH COAST
22	Chiquito Peak	1,021	742	1,271	151	529	83	30	2,963	12	62	0	62	38	259	3	7	3	0	4	1	23	1	0	1	SOUTH COAST
23	Flinn Springs	431	216	666	80	450	0	0	2,728	11	93	93	0	7	275	1	5	6	63	0	0	0	0	0	1	SOUTH COAST
24	Mission Gorge	162	40	356	66	316	0	1	2,536	10	98	92	6	2	276	7	10	17	100	16	1	56	2	4	1	SOUTH COAST
25		-65	-70	-56	3	14	0	0	2,115	9	93	93	0	7	255	2	0	6	0	0	0	0	0	0	1	SONORAN DESERT
26		225	95	478	87	383	96	14	9,684	39	100	0	100	0	224	17	1	2	0	100	1	0	0	0	1	SONORAN DESERT
27	Miramar	201	119	298	38	179	71	27	5,884	24	96	13	83	4	279	2	11	10	100	0	0	44	3	1	1	SOUTH COAST
28	East Mesa/Laguna Mountains	1,430	1,106	1,766	144	660	82	29	32,586	132	88	43	45	12	263	6	29	18	74	5	2	36	3	1	1	SOUTH COAST
29	San Felipe Creek	-27	-51	-2	9	49	100	0	7,203	29	95	94	1	5	169	6	1	5	0	7	1	0	0	1	1	SONORAN DESERT
30	Cuyamaca Mountains	1,314	818	1,972	211	1,154	75	34	23,691	96	91	82	9	9	265	2	26	15	73	0	0	4	1	0	1	SOUTH COAST
31	Inkopah/Tierra Blanca/Jacumba Mountains	937	206	1,936	393	1,730	92	20	227,851	922	91	67	24	9	243	20	51	25	23	57	2	4	2	0	2	SONORAN DESERT, SOUTH COAST
32	Los Penasquitos	82	10	138	32	128	0	0	3,665	15	90	90	0	10	275	2	18	17	100	5	1	2	1	7	1	SOUTH COAST
33	Canada de San Vicente/Iron Mountain	438	138	809	116	671	46	28	15,214	62	67	63	5	33	266	10	15	13	100	0	0	5	2	0	1	SOUTH COAST
34	Anza-Borrego Desert	410	-3	1,624	318	1,627	96	17	298,486	1,208	97	92	5	3	193	20	25	27	11	75	1	0	0	0	1	SONORAN DESERT
35	Woodson Mountain	451	167	872	165	705	32	33	2,865	12	78	78	0	22	267	9	5	6	59	0	0	7	1	1	1	SOUTH COAST
36	Black Mountain	240	54	474	93	420	0	0	2,690	11	88	88	0	12	281	1	6	5	58	0	0	0	0	1	1	SOUTH COAST
37	El Capitan	721	150	1,269	242	1,119	88	19	75,117	304	60	19	41	40	261	7	22	17	69	13	2	1	2	0	1	SOUTH COAST
38		355	197	621	92	424	78	35	7,682	31	100	100	0	0	207	17	4	4	0	77	1	0	0	0	1	SONORAN DESERT
39	Santa Maria	362	122	590	118	468	31	32	4,859	20	63	63	0	37	256	2	8	15	0	20	3	59	6	1	1	SOUTH COAST
40	San Pasqual Valley	129	90	354	44	264	1	6	3,575	14	98	98	0	2	260	7	3	17	0	0	1	59	2	9	1	SOUTH COAST
41	Santa Ysabel	844	514	1,142	126	628	77	24	22,425	91	29	19	10	71	261	4	11	16	100	0	0	15	3	0	1	SOUTH COAST
42	San Felipe Hills/Pinyon Ridge	878	195	1,413	295	1,218	87	28	46,425	188	94	81	13	6	238	17	17	19	68	59	1	0	0	0	2	SONORAN DESERT, SOUTH COAST
43	Borrego Badlands	187	56	390	70	334	92	20	45,737	185	97	97	0	3	172	13	7	3	0	3	1	0	0	0	1	SONORAN DESERT
44	Volcan Mountains	1,171	753	1,734	220	981	83	24	36,253	147	57	18	38	43	266	6	15	21	100	0	1	1	1	0	2	SONORAN DESERT, SOUTH COAST
45	Burnt Mountain	449	220	647	77	427	2	4	3,477	14	93	92	0	7	261	1	2	1	0	23	1	0	0	2	1	SOUTH COAST
46	Black Mountain/Guejito Creek	713	114	1,384	274	1,270	74	27	73,641	298	45	16	28	55	261	4	14	22	41	1	1	31	4	1	1	SOUTH COAST
47	Pine Hills	1,081	720	1,608	195	888	62	35	6,811	28	44	0	44	56	261	2	2	2	57	0	1	0	2	0	1	SOUTH COAST
48	Pala Mountain	314	126	642	110	516	65	15	5,065	20	14	14	0	86	264	1	6	1	87	6	1	100	2	1	1	SOUTH COAST
49	Couser Canyon	261	91	550	135	459	62	23	2,373	10	0	0	0	100	269	3	5	7	25	36	3	100	2	4	1	SOUTH COAST
50	Chocolate Mountains	394	-64	1,366	221	1,430	97	11	1,125,218	4,554	95	72	23	5	170	15	27	30	2	66	2	0	0	0	1	SONORAN DESERT
51	Tourmaline Queen Mountain	411	132	677	129	545	64	19	4,167	17	0	0	0	100	266	6	9	3	100	0	0	100	2	0	1	SOUTH COAST
52	Palomar Mountains	1,045	210	1,868	330	1,658	88	20	99,743	404	66	46	20	34	271	6	36	23	87	3	5	28	6	2	1	SOUTH COAST

Characteristics of Natural Landscape Blocks

	Ecoregions		Watershed		ACEC	Counties		Land Cover								
ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
1	1	East Mesa-Sand Hills	1	IMPERIAL	0	1	Imperial	0	86	0	9	2	1	0	0	3
2	2	Imperial Valley, East Mesa-Sand Hills	1	IMPERIAL	0	1	Imperial	0	77	0	17	0	0	0	1	4
3	1	East Mesa-Sand Hills	1	IMPERIAL	99	1	Imperial	0	38	0	0	0	0	0	0	61
4	2	Palomar-Cuyamaca Peak, Desert Slopes NA No Description	1	ANZA BORREGO	0	1	San Diego	19	51	28	0	0	1	0	0	0
5	1	Palomar-Cuyamaca Peak	2	ANZA BORREGO, TIJUANA	0	1	San Diego	5	59	34	0	0	2	0	0	0
6	1	East Mesa-Sand Hills	2	AMOS-OGILBY, IMPERIAL	0	1	Imperial	0	1	0	0	0	0	0	0	99
7	1	Palomar-Cuyamaca Peak	1	TIJUANA	0	1	San Diego	6	76	16	0	0	2	0	0	0
8	3	Desert Slopes NA No Description, Borrego Valley-West Mesa, Imperial Valley	2	DAVIES, IMPERIAL	44	1	Imperial	1	59	1	15	0	0	0	0	24
9	2	Borrego Valley-West Mesa, Imperial Valley	1	IMPERIAL	100	1	Imperial	0	39	0	29	0	0	0	0	32
10	1	Coastal Terraces	1	TIJUANA	0	1	San Diego	0	13	13	31	4	18	19	0	2
11	1	Palomar-Cuyamaca Peak	1	TIJUANA	0	1	San Diego	4	79	15	1	0	1	0	0	0
12	1	East Mesa-Sand Hills	1	IMPERIAL	0	1	Imperial	0	92	0	8	0	0	0	0	0
13	1	Palomar-Cuyamaca Peak	1	TIJUANA	0	1	San Diego	4	82	11	0	0	3	0	0	0
14	3	Coastal Hills, Coastal Terraces, Western Granitic Foothills	2	OTAY, TIJUANA	3	1	San Diego	0	83	12	2	0	2	0	0	0
15	1	East Mesa-Sand Hills	1	AMOS-OGILBY	0	1	Imperial	0	28	0	69	0	0	0	0	3
16	2	Coastal Hills, Coastal Terraces	2	OTAY, SWEETWATER	0	1	San Diego	0	86	9	2	0	4	0	0	0
17	3	Coastal Hills, Western Granitic Foothills, Palomar-Cuyamaca Peak	3	OTAY, SWEETWATER, TIJUANA	0	1	San Diego	6	84	7	1	0	2	0	0	0
18	3	Chocolate Mountains and Valleys, East Mesa-Sand Hills, Gila Bend Plain Desert Shrubland	3	AMOS-OGILBY, COLORADO, YUMA	0	1	Imperial	0	25	0	15	0	0	0	0	60
19	3	Coastal Hills, Western Granitic Foothills, Palomar-Cuyamaca Peak	3	OTAY, SWEETWATER, TIJUANA	0	1	San Diego	2	87	6	2	0	4	0	0	0
20	1	Palomar-Cuyamaca Peak	2	SWEETWATER, TIJUANA	0	1	San Diego	18	72	6	2	0	1	0	0	0
21	2	Western Granitic Foothills, Palomar-Cuyamaca Peak	2	SWEETWATER, TIJUANA	0	1	San Diego	1	83	10	0	0	5	0	0	0
22	2	Western Granitic Foothills, Palomar-Cuyamaca Peak	2	SAN DIEGO, SWEETWATER	0	1	San Diego	3	87	6	1	0	4	0	0	0
23	2	Coastal Hills, Western Granitic Foothills	2	SAN DIEGO, SWEETWATER	0	1	San Diego	0	87	0	0	0	11	0	0	0
24	2	Coastal Hills, Coastal Terraces	1	SAN DIEGO	0	1	San Diego	0	70	17	4	0	9	0	0	0
25	2	Coachella Valley, Imperial Valley	2	IMPERIAL, SALTON SEA	0	1	Imperial	0	18	0	15	23	3	17	22	2
26	1	Chocolate Mountains and Valleys	1	COLORADO	0	1	Imperial	0	45	0	18	0	0	0	0	38
27	2	Coastal Hills, Coastal Terraces	2	PENASQUITOS, SAN DIEGO	0	1	San Diego	0	83	8	0	0	8	0	0	0
28	1	Palomar-Cuyamaca Peak	4	ANZA BORREGO, SAN DIEGO, SWEETWATER, TIJUANA	0	1	San Diego	32	55	7	1	0	3	0	0	2
29	1	Borrego Valley-West Mesa	1	ANZA BORREGO	67	1	Imperial	0	92	0	4	0	0	0	0	5
30	2	Western Granitic Foothills, Palomar-Cuyamaca Peak	3	ANZA BORREGO, SAN DIEGO, SWEETWATER	0	1	San Diego	39	53	3	2	0	3	0	0	0
31	3	Palomar-Cuyamaca Peak, Desert Slopes NA No Description, Borrego Valley-West Mesa	5	ANZA BORREGO, IMPERIAL, SAN DIEGO, SWEETWATER, TIJUANA	6	2	Imperial, San Diego	12	47	20	0	0	1	0	0	19
32	1	Coastal Terraces	1	PENASQUITOS	0	1	San Diego	1	57	14	13	0	14	0	0	0
33	2	Coastal Hills, Western Granitic Foothills	3	PENASQUITOS, SAN DIEGO, SAN DIEGUITO	0	1	San Diego	1	83	8	1	1	4	0	0	3
34	2	Desert Slopes NA No Description, Borrego Valley-West Mesa	2	ANZA BORREGO, IMPERIAL	7	2	Imperial, San Diego	2	59	4	2	0	1	0	0	32
35	1	Western Granitic Foothills	3	PENASQUITOS, SAN DIEGO, SAN DIEGUITO	0	1	San Diego	1	68	0	2	2	15	1	0	12
36	2	Coastal Hills, Coastal Terraces	2	PENASQUITOS, SAN DIEGUITO	0	1	San Diego	0	62	17	0	0	19	0	0	1
37	3	Coastal Hills, Western Granitic Foothills, Palomar-Cuyamaca Peak	3	SAN DIEGO, SAN DIEGUITO, SWEETWATER	0	1	San Diego	2	89	6	1	0	2	0	0	0
38	2	Desert Slopes NA No Description, Borrego Valley-West Mesa	1	ANZA BORREGO	0	1	San Diego	0	87	0	0	0	1	0	0	13
39	1	Western Granitic Foothills	1	SAN DIEGUITO	0	1	San Diego	1	62	29	0	0	2	6	1	0
40	2	Coastal Hills, Western Granitic Foothills	1	SAN DIEGUITO	0	1	San Diego	0	25	13	12	0	16	25	8	0
41	1	Western Granitic Foothills	1	SAN DIEGUITO	0	1	San Diego	1	74	22	2	0	2	0	0	0
42	3	Palomar-Cuyamaca Peak, Desert Slopes NA No Description, Borrego Valley-West Mesa	2	ANZA BORREGO, SAN LUIS REY	0	1	San Diego	15	63	15	0	0	1	0	0	7
43	1	Borrego Valley-West Mesa	3	ANZA BORREGO, CLARK, WEST SALTON	0	1	San Diego	0	79	0	0	0	1	0	0	20
44	3	Western Granitic Foothills, Palomar-Cuyamaca Peak, Desert Slopes NA No Description	4	ANZA BORREGO, SAN DIEGO, SAN DIEGUITO, SAN LUIS REY	0	1	San Diego	33	50	13	1	0	3	0	0	0
45	1	Western Granitic Foothills	2	CARLSBAD, SAN LUIS REY	0	1	San Diego	0	91	1	1	2	4	1	0	0
46	2	Western Granitic Foothills, Palomar-Cuyamaca Peak	3	CARLSBAD, SAN DIEGUITO, SAN LUIS REY	0	1	San Diego	4	78	13	2	0	2	0	0	0
47	1	Palomar-Cuyamaca Peak	1	SAN LUIS REY	0	1	San Diego	16	62	12	4	0	2	0	1	4
48	1	Western Granitic Foothills	1	SAN LUIS REY	0	1	San Diego	0	93	2	1	0	1	2	2	0
49	2	Santa Ana Mountains, Western Granitic Foothills	1	SAN LUIS REY	0	1	San Diego	0	82	3	1	0	1	13	0	0
50	6	Chuckwalla Valley, Palo Verde Valley and Mesa, Chocolate Mountains and Valleys, Coachella Valley, Imperial Valley, East Mesa-Sand Hills	7	AMOS-OGILBY, CHUCKWALLA, COLORADO, EAST SALTON, HAYFIELD, IMPERIAL, WHITEWATER	48	2	Riverside, Imperial	0	32	0	29	0	0	0	0	39
51	1	Western Granitic Foothills	1	SAN LUIS REY	0	1	San Diego	0	93	2	1	0	2	2	0	0
52	4	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains, Western Granitic Foothills, Palomar-Cuyamaca Peak	2	SAN LUIS REY, SANTA MARGARITA	0	2	Riverside, San Diego	24	62	11	2	0	1	0	0	1

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
53		154	144	163	5	19	83	31	2,108	9	95	88	7	5	160	0	1	0	0	0	0	0	0	0	1	SONORAN DESERT
54	Sandia Canyon	294	85	441	85	356	66	23	2,053	8	58	7	51	42	273	8	4	4	100	15	3	100	3	1	1	SOUTH COAST
55		308	22	550	126	528	98	10	30,969	125	86	76	10	14	214	10	4	8	0	23	1	0	0	0	1	SONORAN DESERT
56	Temecula Canyon	390	145	710	120	565	27	20	6,444	26	87	87	0	13	272	5	9	16	100	96	3	88	2	1	1	SOUTH COAST
57		262	202	391	29	189	97	12	8,204	33	90	0	90	10	165	4	3	1	0	71	1	0	0	0	1	SONORAN DESERT
58	Vail Lake	554	375	838	93	463	71	20	10,987	44	7	0	7	93	271	4	12	16	100	78	3	14	5	2	1	SOUTH COAST
59	Santa Rosa Mountains	963	-18	2,644	500	2,662	94	17	466,607	1,888	88	78	10	12	241	21	63	34	15	60	4	1	2	0	2	SONORAN DESERT, SOUTH COAST
60	Big Maria Mountains	346	89	1,011	144	922	98	10	91,291	369	100	99	1	0	192	33	1	1	0	0	0	0	0	0	1	SONORAN DESERT
61	Magee Hills	714	590	822	49	232	71	18	2,845	12	0	0	0	100	260	8	0	5	100	17	2	1	1	0	1	SOUTH COAST
62	Riverside Mountains	296	117	674	91	557	NoData	NoData	25,360	103	100	98	1	0	229	22	1	7	0	0	0	0	0	0	1	SONORAN DESERT
63	Warm Springs Creek	443	390	494	21	104	1	4	2,378	10	95	95	0	5	264	1	5	4	0	76	3	3	1	0	1	SOUTH COAST
64	Lake Skinner	563	416	916	94	500	72	24	18,114	73	36	31	5	64	264	1	10	11	97	80	3	10	1	0	1	SOUTH COAST
65		58	33	101	13	68	16	27	4,649	19	96	96	0	4	189	2	2	4	0	98	1	99	1	0	1	SONORAN DESERT
66	Cahuilla Moutain/Rouse Ridge	1,147	583	2,068	286	1,485	86	22	76,219	308	74	50	23	26	256	6	16	24	61	13	4	6	2	0	1	SOUTH COAST
67	Palen Mountains	362	119	1,319	186	1,200	98	9	228,480	925	100	99	1	0	158	3	3	5	0	0	0	0	0	0	1	SONORAN DESERT
68	Camp Pendleton/Santa Rosa	401	7	1,085	253	1,078	84	22	173,747	703	86	32	55	14	282	15	35	42	92	2	6	55	9	1	1	SOUTH COAST
69	Aliso Creek	129	10	313	69	303	0	0	4,409	18	92	92	0	8	297	18	12	10	0	0	1	3	1	2	1	SOUTH COAST
70	San Joaquin Hills South	176	7	342	63	335	0	1	6,861	28	97	97	0	3	303	16	12	11	0	0	0	0	0	1	1	SOUTH COAST
71	San Joaquin Hills North	178	77	319	53	242	0	0	3,429	14	94	94	0	6	271	1	6	9	0	0	0	0	0	1	1	SOUTH COAST
72		339	282	448	34	166	92	22	3,706	15	98	95	3	2	151	1	0	0	0	0	0	0	0	0	1	SONORAN DESERT
73	Indio Hills	249	62	502	88	440	62	45	15,957	65	93	92	1	7	201	12	3	7	0	28	1	0	0	0	1	SONORAN DESERT
74	San Jacinto Mountains	1,290	69	3,290	656	3,221	74	35	177,816	720	90	80	10	10	271	19	49	39	76	39	2	2	3	0	2	SONORAN DESERT, SOUTH COAST
75	Estelle Mountain	510	298	841	118	543	42	21	7,367	30	80	64	16	20	274	8	5	11	0	96	3	2	2	0	1	SOUTH COAST
76	Indian Mountain/Gilman Springs	1,010	451	1,781	304	1,330	77	32	48,455	196	86	27	59	14	269	6	11	17	87	1	3	0	1	0	1	SOUTH COAST
77	Loma Ridge	362	168	537	71	369	41	42	9,369	38	52	52	0	48	273	4	2	15	0	0	1	45	2	0	1	SOUTH COAST
78	Mount Eden/Badlands	592	437	751	66	314	84	25	6,575	27	1	0	1	99	268	1	3	10	100	0	0	0	2	0	1	SOUTH COAST
79	Lake Perris	548	432	816	85	384	45	48	9,131	37	97	80	18	3	266	1	6	11	100	0	0	9	3	0	1	SOUTH COAST
80	Pinto Basin/ Eagle Mountain	654	154	1,622	224	1,468	96	15	551,784	2,233	99	98	1	1	163	8	18	15	0	43	1	0	0	0	2	SONORAN DESERT, MOJAVE DESERT
81	Lake Matthews	436	386	487	15	101	19	18	3,912	16	99	99	0	1	271	3	3	7	0	0	0	95	2	0	1	SOUTH COAST
82	The Badlands East	576	439	743	58	304	82	23	3,439	14	15	0	15	85	267	1	1	5	100	0	0	0	2	0	1	SOUTH COAST
83		1,198	633	1,721	192	1,088	96	15	55,546	225	100	100	0	0	184	6	7	14	0	0	0	0	0	0	1	MOJAVE DESERT
84	The Badlands West	676	578	803	44	225	72	16	3,324	13	34	1	33	66	266	2	3	3	100	0	0	0	0	0	1	SOUTH COAST
85	Santa Ana Mountains	694	74	1,712	287	1,638	89	26	109,570	443	89	58	31	11	276	7	33	30	6	7	3	59	6	0	1	SOUTH COAST
86	Little San Bernardino Mountains	1,060	327	1,769	268	1,442	95	18	368,619	1,492	98	97	2	2	203	23	15	23	0	20	1	0	0	0	2	SONORAN DESERT, MOJAVE DESERT
87	Box Springs Mountains	634	295	932	142	637	0	0	3,292	13	93	93	0	7	267	1	6	4	100	66	1	0	0	0	1	SOUTH COAST
88	Prado Basin	157	141	183	8	42	22	23	5,215	21	64	64	0	36	271	5	0	7	0	82	1	62	2	0	1	SOUTH COAST
89	Chino Hills	304	118	543	88	425	32	45	14,924	60	88	87	0	12	267	9	4	13	0	33	2	10	2	0	1	SOUTH COAST
90	Cleghorn Lakes	666	414	1,238	179	824	98	10	40,352	163	100	98	2	0	145	1	0	3	0	0	0	0	0	0	1	MOJAVE DESERT
91	Cadiz Valley	201	169	297	27	128	98	10	21,323	86	100	98	2	0	147	2	1	0	0	0	0	0	0	0	2	SONORAN DESERT, MOJAVE DESERT
92	Sheep Hole Mountains	481	172	1,398	192	1,226	97	14	196,742	796	100	100	0	0	147	4	4	5	0	1	1	0	0	0	2	SONORAN DESERT, MOJAVE DESERT
93	Sugarloaf Mountain/Keller Peak	1,673	468	3,029	597	2,561	86	25	73,431	297	94	31	62	6	267	10	38	12	79	2	8	0	2	0	1	SOUTH COAST
94	Glen Helen	549	475	699	36	224	66	14	2,215	9	0	0	0	100	273	3	2	4	99	93	1	100	1	0	1	SOUTH COAST
95	McKinley Mountain/Arrowhead Peak	1,174	503	1,909	270	1,406	70	42	15,646	63	98	62	35	2	272	5	7	8	0	6	2	0	0	0	1	SOUTH COAST
96		480	161	1,248	158	1,087	84	30	285,169	1,154	100	100	0	0	192	28	12	5	0	31	1	0	0	0	2	SONORAN DESERT, MOJAVE DESERT

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
53	1	Chuckwalla Valley	1	CHUCKWALLA	88	1	Riverside	0	55	0	1	0	0	1	0	43
54	1	Santa Ana Mountains	1	SANTA MARGARITA	0	1	San Diego	1	90	1	0	0	3	4	0	0
55	2	Chocolate Mountains and Valleys, Coachella Valley	1	WHITEWATER	28	1	Riverside	0	33	0	30	0	0	0	0	37
56	2	Santa Ana Mountains, Western Granitic Foothills	1	SANTA MARGARITA	84	2	Riverside, San Diego	1	92	2	1	0	2	1	0	0
57	1	Chuckwalla Valley	1	CHUCKWALLA	100	1	Riverside	0	67	0	25	0	0	0	0	8
58	2	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	1	SANTA MARGARITA	0	1	Riverside	3	74	15	3	0	1	0	1	1
59	7	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains, Palomar-Cuyamaca Peak, Desert Slopes NA No Description, Coachella Valley, Borrego Valley-West Mesa	7	ANZA BORREGO, CLARK, SAN JACINTO VALLEY, SAN LUIS REY, SANTA MARGARITA, WEST SALTON, WHITEWATER	2	3	Riverside, Imperial, San Diego	28	43	10	1	0	1	0	0	18
60	3	Cadiz-Vidal Valleys, Palen-Riverside Mountains, Palo Verde Valley and Mesa	2	COLORADO, RICE	0	1	Riverside	0	53	0	7	0	0	0	0	40
61	2	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	2	SAN JACINTO VALLEY, SANTA MARGARITA	0	1	Riverside	7	75	14	0	0	2	0	0	2
62	3	Cadiz-Vidal Valleys, Palen-Riverside Mountains, Palo Verde Valley and Mesa	2	COLORADO, RICE	0	1	Riverside	0	57	0	10	0	0	0	0	33
63	1	Perris Valley and Hills	2	SAN JACINTO VALLEY, SANTA MARGARITA	0	1	Riverside	0	58	27	0	0	14	0	1	0
64	2	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	1	SANTA MARGARITA	0	1	Riverside	1	76	9	1	7	5	0	0	1
65	1	Coachella Valley	1	WHITEWATER	0	1	Riverside	0	44	0	43	0	1	0	0	11
66	2	San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains	2	SAN JACINTO VALLEY, SANTA MARGARITA	0	1	Riverside	28	62	7	0	0	2	0	0	1
67	3	Cadiz-Vidal Valleys, Palen-Riverside Mountains, Chuckwalla Valley	4	CHUCKWALLA, COLORADO, RICE, WARD	0	1	Riverside	0	36	0	5	0	0	0	0	60
68	4	Coastal Hills, Coastal Terraces, Santa Ana Mountains, Perris Valley and Hills	3	SAN JACINTO VALLEY, SAN JUAN, SANTA MARGARITA	0	3	Riverside, Orange, San Diego	0	80	11	2	0	4	0	0	3
69	2	Coastal Hills, Coastal Terraces	1	SAN JUAN	0	1	Orange	1	78	3	5	0	11	0	0	1
70	2	Coastal Hills, Coastal Terraces	2	SAN JUAN, SANTA ANA RIVER	0	1	Orange	0	91	2	1	0	6	0	0	0
71	1	Coastal Hills	2	SAN JUAN, SANTA ANA RIVER	0	1	Orange	0	83	5	3	0	9	0	0	0
72	1	Cadiz-Vidal Valleys	1	WARD	0	2	San Bernardino, Riverside	0	97	0	0	0	0	0	0	2
73	1	Coachella Valley	1	WHITEWATER	58	1	Riverside	0	56	0	24	0	1	0	0	19
74	5	Fontana Plain-Calimesa Terraces, San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains, Desert Slopes NA No Description, Coachella Valley	2	SAN JACINTO VALLEY, WHITEWATER	0	1	Riverside	46	29	13	1	0	1	0	0	11
75	1	Perris Valley and Hills	1	SANTA ANA RIVER	0	1	Riverside	3	56	31	2	0	8	0	0	1
76	4	Fontana Plain-Calimesa Terraces, Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains, San Jacinto Mountains	2	SAN JACINTO VALLEY, WHITEWATER	26	1	Riverside	19	59	18	0	0	2	0	0	1
77	2	Los Angeles Plain, Coastal Hills	2	SAN JUAN, SANTA ANA RIVER	0	1	Orange	0	87	6	0	0	7	0	0	0
78	2	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	1	SAN JACINTO VALLEY	0	1	Riverside	1	66	30	0	0	1	0	0	2
79	1	Perris Valley and Hills	1	SAN JACINTO VALLEY	0	1	Riverside	6	49	31	1	2	10	0	0	1
80	6	Lucerne-Johnson Valleys and Hills, Bullion Mountains-Bristol Lake, Pinto Basin and Mountains, Cadiz-Vidal Valleys, Chuckwalla Valley, Chocolate Mountains and Valleys	6	CADIZ, CHUCKWALLA, DALE, HAYFIELD, ROUTE SIXTY SIX, WHITEWATER	23	2	San Bernardino, Riverside	0	40	0	4	0	0	0	0	56
81	1	Perris Valley and Hills	1	SANTA ANA RIVER	0	1	Riverside	1	34	42	0	11	10	1	0	0
82	2	Perris Valley and Hills, San Jacinto Foothills-Cahuilla Mountains	1	SAN JACINTO VALLEY	0	1	Riverside	1	66	30	1	0	1	0	0	1
83	2	Lucerne-Johnson Valleys and Hills, Pinto Basin and Mountains	2	DALE, JOSHUA TREE	0	2	San Bernardino, Riverside	0	44	0	1	0	0	0	0	55
84	2	Fontana Plain-Calimesa Terraces, San Jacinto Foothills-Cahuilla Mountains	2	SAN JACINTO VALLEY, SANTA ANA RIVER	0	1	Riverside	2	79	15	0	0	1	0	2	1
85	5	Los Angeles Plain, Coastal Hills, Santa Ana Mountains, Fontana Plain-Calimesa Terraces, Perris Valley and Hills	3	SAN JACINTO VALLEY, SAN JUAN, SANTA ANA RIVER	0	2	Riverside, Orange	5	88	2	1	0	3	0	0	1
86	5	Little San Bernardino-Bighorn Mountains, Lucerne-Johnson Valleys and Hills, Pinto Basin and Mountains, Chocolate Mountains and Valleys, Coachella Valley	4	CHUCKWALLA, DALE, JOSHUA TREE, WHITEWATER	8	2	San Bernardino, Riverside	0	36	0	2	0	0	0	0	62
87	2	Fontana Plain-Calimesa Terraces, Perris Valley and Hills	2	SAN JACINTO VALLEY, SANTA ANA RIVER	0	1	Riverside	10	53	30	0	0	7	0	0	1
88	2	Santa Ana Mountains, Fontana Plain-Calimesa Terraces	1	SANTA ANA RIVER	0	2	San Bernardino, Riverside	0	15	15	43	2	13	10	3	0
89	3	Los Angeles Plain, Santa Ana Mountains, Fontana Plain-Calimesa Terraces	1	SANTA ANA RIVER	0	3	San Bernardino, Riverside, Orange	2	75	14	2	0	6	0	0	0
90	2	Lucerne-Johnson Valleys and Hills, Bullion Mountains-Bristol Lake	2	DALE, ROUTE SIXTY SIX	0	1	San Bernardino	0	48	0	4	0	0	0	0	48
91	1	Cadiz-Vidal Valleys	1	CADIZ	0	1	San Bernardino	0	67	0	2	0	0	0	0	31
92	2	Bullion Mountains-Bristol Lake, Cadiz-Vidal Valleys	4	CADIZ, CHUCKWALLA, DALE, ROUTE SIXTY SIX	6	1	San Bernardino	0	75	0	2	0	0	0	0	23
93	2	San Gorgonio Mountains, Upper San Gorgonio Mountains	3	JOHNSON, MOJAVE, SANTA ANA RIVER	0	1	San Bernardino	59	33	3	1	0	4	0	0	0
94	2	San Gabriel Mountains, Fontana Plain-Calimesa Terraces	1	SANTA ANA RIVER	0	1	San Bernardino	0	43	22	2	0	32	0	0	2
95	2	San Gorgonio Mountains, Upper San Gorgonio Mountains	2	MOJAVE, SANTA ANA RIVER	0	1	San Bernardino	31	57	3	3	0	1	0	0	5
96	2	Piute Valley-Sacramento Mountains, Cadiz-Vidal Valleys	3	CHEMEHUEVIS, COLORADO, HOMER	41	1	San Bernardino	0	25	0	17	0	0	0	0	58

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
97	Lytle Creek Ridge	843	604	1,162	137	558	90	18	4,318	17	79	0	79	21	278	10	3	4	4	15	2	3	1	0	1	SOUTH COAST
98	San Dimas	879	305	1,761	294	1,456	75	40	25,420	103	91	75	16	9	272	10	11	9	0	1	1	1	1	0	1	SOUTH COAST
99	The Pinnacles	1,339	942	1,772	184	830	88	26	15,838	64	92	7	85	8	282	15	6	11	0	0	0	82	2	0	2	SOUTH COAST, MOJAVE DESERT
100	Las Flores/Santa Monica Mtns	296	8	663	122	655	17	30	3,465	14	90	90	0	10	302	13	3	4	0	0	1	100	1	1	1	SOUTH COAST
101	San Bernardino Mountains	1,720	433	3,503	564	3,070	90	19	289,282	1,171	91	72	19	9	258	21	64	32	52	3	11	0	1	0	3	SONORAN DESERT, SOUTH COAST, MOJAVE DESERT
102	Butler Peak/White Mountains/Grapevine Canyon	1,787	917	2,588	320	1,671	86	25	75,173	304	96	33	63	4	270	11	43	18	58	4	10	18	2	0	2	SOUTH COAST, MOJAVE DESERT
103	Cleghorn Ridge	1,208	580	1,729	229	1,149	84	31	22,831	92	88	35	53	12	273	13	9	10	0	0	1	17	2	0	2	SOUTH COAST, MOJAVE DESERT
104	Mount Hollywood	271	130	537	79	407	0	0	3,947	16	94	94	0	6	244	3	4	3	0	0	0	0	0	0	1	SOUTH COAST
105		1,360	1,233	1,498	54	265	75	29	2,535	10	98	94	4	2	252	4	0	0	0	0	0	0	0	0	1	MOJAVE DESERT
106	Zuma/Trancas Canyons/Santa Monica Mtns	313	4	756	180	752	39	41	10,129	41	98	98	0	2	297	18	3	4	0	2	2	100	1	1	1	SOUTH COAST
107	Castro Peak/Santa Monica Mtns	362	9	856	175	847	24	39	19,846	80	100	100	0	0	277	17	11	14	0	0	1	100	1	2	1	SOUTH COAST
108	Alisos Canyon/Santa Monica Mtns	318	3	553	127	550	44	27	3,867	16	94	94	0	6	296	19	3	2	0	0	0	100	1	1	1	SOUTH COAST
109	Calabasas Peak/Santa Monica Mtns	382	1	855	148	854	6	20	13,100	53	97	97	0	3	276	15	10	12	0	0	1	88	1	1	1	SOUTH COAST
110	Topanga Canyon/Santa Monica Mtns	389	27	642	108	615	47	46	20,042	81	96	96	0	4	275	15	3	5	0	2	1	23	1	1	1	SOUTH COAST
111	Liberty Canyon/Santa Monica Mtns	291	168	445	57	277	0	0	3,567	14	97	97	0	3	269	1	1	4	0	0	0	100	1	2	1	SOUTH COAST
112	Las Virgenes Creek/Santa Monica Mtns	332	186	522	66	336	0	0	5,038	20	98	98	0	2	268	1	4	2	0	0	0	92	1	0	1	SOUTH COAST
113	Verdugo Mountains	558	236	950	145	714	0	0	7,265	29	93	93	0	7	230	2	6	1	0	0	0	0	0	0	1	SOUTH COAST
114	Lobo Canyon/Santa Monica Mtns	449	250	739	115	489	0	2	3,319	13	97	96	1	3	270	3	3	2	0	15	1	100	2	0	1	SOUTH COAST
115		673	555	831	58	276	85	29	7,850	32	100	100	0	0	145	1	0	1	0	100	1	0	0	0	1	MOJAVE DESERT
116	Turtle Mountains/ Ward Valley	600	155	1,607	212	1,452	98	11	1,030,509	4,170	99	96	4	1	154	13	5	6	0	67	1	0	0	0	2	SONORAN DESERT, MOJAVE DESERT
117		571	526	620	20	94	91	23	12,175	49	100	100	0	0	145	0	0	1	0	100	1	0	0	0	1	MOJAVE DESERT
118	Clipper Mountains	678	317	1,394	179	1,077	99	8	123,120	498	100	89	11	0	144	1	2	3	0	76	1	0	0	0	1	MOJAVE DESERT
119	Table Mountain	1,855	1,560	2,250	146	690	90	19	4,030	16	86	0	86	14	288	14	4	4	0	0	0	0	0	0	2	SOUTH COAST, MOJAVE DESERT
120	San Gabriel/Cucamonga	1,377	208	3,065	540	2,857	88	24	241,279	976	95	67	28	5	261	12	44	22	1	4	4	40	2	0	2	SOUTH COAST, MOJAVE DESERT
121	Point Mugu	356	2	924	184	922	54	37	31,975	129	91	91	0	9	280	17	9	8	0	2	1	92	2	0	1	SOUTH COAST
122	Big Tujunga Canyon	858	423	1,496	234	1,073	80	34	6,707	27	92	1	91	8	255	11	4	5	0	12	1	97	2	0	1	SOUTH COAST
123	Hope Nature	340	206	478	48	272	0	2	4,336	18	95	95	0	5	272	2	5	2	0	5	1	62	1	0	1	SOUTH COAST
124	Simi Hills	435	239	721	92	482	0	0	15,157	61	95	95	0	5	257	5	5	9	0	5	1	80	1	1	1	SOUTH COAST
125		688	360	1,075	134	715	90	24	38,361	155	100	99	0	0	148	9	2	2	0	92	1	0	0	0	1	MOJAVE DESERT
126		762	625	1,096	55	471	91	24	13,897	56	100	100	0	0	144	0	2	1	0	100	1	0	0	0	1	MOJAVE DESERT
127	Mount Clef Ridge	187	71	354	58	283	0	0	3,290	13	88	88	0	12	261	1	4	2	0	26	1	0	0	2	1	SOUTH COAST
128	Sidewinder Mountain	1,147	935	1,506	130	571	90	21	9,892	40	99	97	2	1	149	1	0	2	0	0	0	0	0	0	1	MOJAVE DESERT
129	Contract Point	805	431	1,224	174	793	86	30	9,714	39	81	13	69	19	268	13	6	3	0	0	1	5	1	0	1	SOUTH COAST
130	Lava	631	573	704	34	131	90	24	12,498	51	99	96	3	1	142	2	2	0	0	0	0	0	0	0	1	MOJAVE DESERT
131	San Gabriel Mountains West	1,119	369	1,983	303	1,614	91	24	94,584	383	95	17	79	5	247	8	8	11	0	1	1	38	2	0	1	SOUTH COAST
132	Pleasant View Ridge	1,544	826	2,555	303	1,729	86	26	97,425	394	98	36	63	2	257	13	19	11	0	2	2	23	2	0	2	SOUTH COAST, MOJAVE DESERT
133	Preston Mine	757	623	1,199	99	576	91	24	13,944	56	100	99	0	0	141	0	3	3	0	0	0	0	0	0	1	MOJAVE DESERT
134	South Mountain	231	46	660	119	614	77	18	4,196	17	25	25	0	75	254	3	0	3	0	0	0	0	0	4	1	SOUTH COAST
135	Long Canyon	333	140	563	81	423	77	14	3,373	14	0	0	0	100	252	1	1	0	0	0	0	0	0	0	1	SOUTH COAST
136	Santa Susana Mountains	579	169	1,022	142	853	57	39	40,875	165	40	39	1	60	256	7	7	15	0	61	2	0	0	1	1	SOUTH COAST
137	Eastern Sierra Pelona	1,356	1,077	1,588	121	511	55	15	2,419	10	96	95	0	4	240	16	0	0	0	0	0	0	0	0	1	SOUTH COAST
138		503	158	1,080	201	922	91	23	76,904	311	100	100	0	0	180	28	1	5	0	41	1	0	0	0	1	MOJAVE DESERT
139	Silver Mountain	997	751	1,282	103	531	89	22	11,648	47	97	97	0	3	178	3	1	1	0	0	0	0	0	0	1	MOJAVE DESERT
140	Big Oak Spring	1,087	652	1,513	202	861	96	13	9,158	37	99	0	99	1	233	2	2	0	0	0	0	0	0	0	1	SOUTH COAST
141	Sulphur Mountain	278	75	590	92	515	73	18	20,836	84	1	0	1	99	263	4	2	3	0	0	1	45	1	1	1	SOUTH COAST

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
97	3	San Gabriel Mountains, San Gorgonio Mountains, Fontana Plain-Calimesa Terraces	1	SANTA ANA RIVER	0	1	San Bernardino	5	89	4	0	0	1	0	0	2
98	3	Los Angeles Plain, San Gabriel Mountains, Upper San Gabriel Mountains	2	SAN GABRIEL RIVER, SANTA ANA RIVER	0	1	Los Angeles	13	80	2	1	0	3	0	0	0
99	4	San Gorgonio Mountains, Upper San Gorgonio Mountains, Little San Bernardino-Bighorn Mountains, High Desert Plains and Hills	1	MOJAVE	0	1	San Bernardino	51	34	11	0	1	2	0	0	0
100	1	Santa Monica Mountains	1	SANTA MONICA BAY	0	1	Los Angeles	2	87	1	0	0	10	0	0	0
101	6	San Gorgonio Mountains, Upper San Gorgonio Mountains, Little San Bernardino-Bighorn Mountains, Fontana Plain-Calimesa Terraces, Lucerne-Johnson Valleys and Hills, Coachella Valley	7	EMERSON, JOHNSON, JOSHUA TREE, LUCERNE LAKE, MEANS, SANTA ANA RIVER, WHITEWATER	8	2	San Bernardino, Riverside	59	23	13	1	0	1	0	0	4
102	5	San Gorgonio Mountains, Upper San Gorgonio Mountains, Little San Bernardino-Bighorn Mountains, High Desert Plains and Hills, Lucerne-Johnson Valleys and Hills	4	JOHNSON, LUCERNE LAKE, MOJAVE, SANTA ANA RIVER	0	1	San Bernardino	69	6	23	0	0	2	0	0	0
103	3	San Gorgonio Mountains, Fontana Plain-Calimesa Terraces, High Desert Plains and Hills	2	MOJAVE, SANTA ANA RIVER	0	1	San Bernardino	35	54	1	2	0	2	0	0	6
104	2	Santa Monica Mountains, Los Angeles Plain	2	LOS ANGELES RIVER, SANTA MONICA BAY	0	1	Los Angeles	0	66	2	1	2	30	0	0	0
105	1	Little San Bernardino-Bighorn Mountains	2	LUCERNE LAKE, MOJAVE	0	1	San Bernardino	1	83	2	5	0	0	0	0	9
106	1	Santa Monica Mountains	1	SANTA MONICA BAY	0	1	Los Angeles	1	79	1	1	0	19	0	0	0
107	1	Santa Monica Mountains	1	SANTA MONICA BAY	0	1	Los Angeles	1	81	1	1	0	15	0	0	0
108	1	Santa Monica Mountains	1	SANTA MONICA BAY	0	1	Los Angeles	1	90	2	0	0	7	0	0	0
109	2	Simi Valley-Santa Susana Mountains, Santa Monica Mountains	2	LOS ANGELES RIVER, SANTA MONICA BAY	0	1	Los Angeles	0	80	2	1	0	17	0	0	0
110	3	Simi Valley-Santa Susana Mountains, Santa Monica Mountains, Los Angeles Plain	2	LOS ANGELES RIVER, SANTA MONICA BAY	0	1	Los Angeles	1	86	1	0	1	12	0	0	0
111	2	Simi Valley-Santa Susana Mountains, Santa Monica Mountains	1	SANTA MONICA BAY	0	1	Los Angeles	0	77	7	2	0	14	0	0	0
112	2	Simi Valley-Santa Susana Mountains, Santa Monica Mountains	2	LOS ANGELES RIVER, SANTA MONICA BAY	0	1	Los Angeles	0	73	14	0	0	11	0	1	0
113	1	Los Angeles Plain	1	LOS ANGELES RIVER	0	1	Los Angeles	1	90	0	0	0	8	0	0	0
114	1	Santa Monica Mountains	1	SANTA MONICA BAY	0	2	Ventura, Los Angeles	0	84	2	1	4	9	0	0	0
115	2	Providence Mountains-Lanfair Valley, Bullion Mountains-Bristol Lake	1	ROUTE SIXTY SIX	99	1	San Bernardino	0	87	0	0	0	0	0	0	13
116	4	Providence Mountains-Lanfair Valley, Piute Valley-Sacramento Mountains, Bullion Mountains-Bristol Lake, Cadiz-Vidal Valleys	7	CADIZ, CHEMEHUEVIS, COLORADO, HOMER, RICE, ROUTE SIXTY SIX, WARD	64	1	San Bernardino	0	58	0	5	0	0	0	0	37
117	2	Providence Mountains-Lanfair Valley, Bullion Mountains-Bristol Lake	1	ROUTE SIXTY SIX	98	1	San Bernardino	0	100	0	0	0	0	0	0	0
118	2	Providence Mountains-Lanfair Valley, Bullion Mountains-Bristol Lake	1	ROUTE SIXTY SIX	57	1	San Bernardino	0	53	0	1	0	0	0	0	46
119	2	San Gabriel Mountains, High Desert Plains and Hills	2	ANTELOPE, MOJAVE	0	2	San Bernardino, Los Angeles	79	4	9	1	0	7	0	0	0
120	5	Los Angeles Plain, San Gabriel Mountains, Upper San Gabriel Mountains, Fontana Plain-Calimesa Terraces, High Desert Plains and Hills	5	ANTELOPE, LOS ANGELES RIVER, MOJAVE, SAN GABRIEL RIVER, SANTA ANA RIVER	0	2	San Bernardino, Los Angeles	47	46	2	1	0	1	0	0	1
121	3	Oxnard Plain-Santa Paula Valley, Simi Valley-Santa Susana Mountains, Santa Monica Mountains	3	CALLEGUAS, SANTA MONICA BAY, VENTURA COASTAL STREAMS	0	2	Ventura, Los Angeles	1	87	2	1	0	7	0	2	0
122	2	Los Angeles Plain, San Gabriel Mountains	1	LOS ANGELES RIVER	0	1	Los Angeles	11	78	1	2	0	7	0	0	0
123	2	Simi Valley-Santa Susana Mountains, Santa Monica Mountains	2	CALLEGUAS, SANTA MONICA BAY	0	1	Ventura	0	64	5	0	0	13	0	17	0
124	1	Simi Valley-Santa Susana Mountains	3	CALLEGUAS, LOS ANGELES RIVER, SANTA MONICA BAY	0	2	Ventura, Los Angeles	0	73	18	1	0	8	0	0	0
125	2	Providence Mountains-Lanfair Valley, Piute Valley-Sacramento Mountains	3	HOMER, ROUTE SIXTY SIX, WARD	92	1	San Bernardino	0	58	0	1	0	0	0	0	41
126	1	Providence Mountains-Lanfair Valley	1	ROUTE SIXTY SIX	100	1	San Bernardino	0	67	0	0	0	0	0	0	33
127	2	Oxnard Plain-Santa Paula Valley, Simi Valley-Santa Susana Mountains	1	CALLEGUAS	0	1	Ventura	0	75	2	5	0	18	0	0	0
128	1	Lucerne-Johnson Valleys and Hills	2	LUCERNE LAKE, MOJAVE	97	1	San Bernardino	0	59	0	1	0	0	0	0	40
129	3	Los Angeles Plain, Sierra Pelona-Mint Canyon, San Gabriel Mountains	2	LOS ANGELES RIVER, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	3	89	1	1	0	6	0	0	0
130	2	Mojave Valley-Granite Mountains, Bullion Mountains-Bristol Lake	3	BROADWELL, LAVIC, MOJAVE	38	1	San Bernardino	0	33	0	0	0	0	0	0	67
131	4	Los Angeles Plain, Sierra Pelona-Mint Canyon, San Gabriel Mountains, Upper San Gabriel Mountains	2	LOS ANGELES RIVER, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	30	63	4	1	0	2	0	0	0
132	4	Sierra Pelona-Mint Canyon, San Gabriel Mountains, Upper San Gabriel Mountains, High Desert Plains and Hills	4	ANTELOPE, LOS ANGELES RIVER, SAN GABRIEL RIVER, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	62	25	12	0	0	1	0	0	0
133	1	Bullion Mountains-Bristol Lake	3	BROADWELL, LAVIC, MOJAVE	99	1	San Bernardino	0	74	0	1	0	0	0	0	25
134	2	Oxnard Plain-Santa Paula Valley, Simi Valley-Santa Susana Mountains	2	CALLEGUAS, SANTA CLARA - CALLEGUAS	0	1	Ventura	0	81	6	7	0	3	2	0	1
135	2	Oxnard Plain-Santa Paula Valley, Simi Valley-Santa Susana Mountains	2	CALLEGUAS, SANTA CLARA - CALLEGUAS	0	1	Ventura	0	86	10	0	0	4	0	0	0
136	4	Oxnard Plain-Santa Paula Valley, Simi Valley-Santa Susana Mountains, Los Angeles Plain, Sierra Pelona-Mint Canyon	3	CALLEGUAS, LOS ANGELES RIVER, SANTA CLARA - CALLEGUAS	0	2	Ventura, Los Angeles	1	83	12	1	0	3	0	0	0
137	1	Sierra Pelona-Mint Canyon	2	ANTELOPE, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	63	27	5	0	0	6	0	0	0
138	1	Piute Valley-Sacramento Mountains	1	HOMER	41	1	San Bernardino	0	64	0	10	0	0	0	0	26
139	2	High Desert Plains and Hills, Lucerne-Johnson Valleys and Hills	1	MOJAVE	94	1	San Bernardino	0	49	0	0	0	0	0	0	51
140	2	Northern Transverse Ranges, Sierra Pelona-Mint Canyon	2	ANTELOPE, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	16	79	4	0	0	1	0	0	0
141	2	Santa Ynez-Sulphur Mountains, Oxnard Plain-Santa Paula Valley	3	BUENAVENTURA, SANTA CLARA - CALLEGUAS, VENTURA RIVER	0	1	Ventura	1	91	3	1	0	2	2	1	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
142	Saddleback Butte	887	783	1,101	62	318	72	34	3,059	12	96	96	0	4	174	1	0	3	0	0	0	0	0	0	1	MOJAVE DESERT
143	Rincon Mountain	326	35	652	114	617	72	10	3,786	15	0	0	0	100	266	11	3	0	0	0	0	0	0	0	1	SOUTH COAST
144	Ord Mountains	1,059	545	1,917	241	1,372	90	23	273,178	1,106	100	97	3	0	149	7	5	3	0	91	1	0	0	0	1	MOJAVE DESERT
145	Jupiter Mountain/Del Sur Ridge	908	503	1,374	174	871	89	26	15,542	63	94	0	94	6	236	7	2	2	0	0	0	0	0	0	1	SOUTH COAST
146		502	372	684	51	312	89	27	16,103	65	97	92	5	3	148	1	0	8	0	0	0	0	0	1	1	MOJAVE DESERT
147	San Francisquito	905	392	1,404	208	1,012	87	27	30,354	123	96	59	38	4	237	8	6	5	0	4	1	0	0	0	1	SOUTH COAST
148	Iron Mountain	747	677	927	39	250	80	28	31,114	126	100	100	0	0	174	3	1	3	0	40	1	0	0	0	1	MOJAVE DESERT
149		747	611	921	67	310	88	24	19,158	78	99	99	0	1	153	10	1	2	0	100	1	0	0	0	1	MOJAVE DESERT
150	Portal Ridge	1,132	901	1,363	90	462	80	25	10,747	43	23	5	18	77	267	12	3	3	0	0	0	0	0	0	2	SOUTH COAST, MOJAVE DESERT
151	Shadow Mountains	903	701	1,244	75	543	79	27	100,195	405	99	84	15	1	166	2	2	2	0	92	1	0	0	0	1	MOJAVE DESERT
152		810	697	1,019	49	322	83	28	99,959	405	100	100	0	0	168	4	3	3	0	100	1	0	0	0	1	MOJAVE DESERT
153	Spring Canyon	1,050	920	1,230	77	310	81	26	8,750	35	73	73	0	27	262	19	0	1	0	0	0	0	0	0	2	SOUTH COAST, MOJAVE DESERT
154	Bristol Mountains/ Devils Playground	674	283	2,049	284	1,766	97	13	591,582	2,394	100	99	0	0	150	10	11	19	0	6	1	0	0	0	1	MOJAVE DESERT
155	San Marcos Pass	550	276	1,086	165	810	88	26	9,851	40	83	0	83	17	287	4	4	2	0	34	1	100	1	0	2	SOUTH COAST, CENTRAL COAST
156	Liebre/Sawmill Mountains	1,051	350	1,763	286	1,413	92	21	93,328	378	95	48	46	5	242	15	5	11	0	0	0	14	2	0	2	SOUTH COAST, MOJAVE DESERT
157	Santa Ynez Mountains Central	372	10	865	207	855	80	22	21,197	86	54	17	37	46	278	19	8	7	0	9	2	100	2	0	2	SOUTH COAST, CENTRAL COAST
158	Santa Ynez Mountains East	492	20	1,306	260	1,286	89	20	45,342	183	65	61	5	35	277	12	10	6	0	0	0	99	1	0	2	SOUTH COAST, CENTRAL COAST
159	Mid Hills/ Ivanpah Valley/ New York Mountains	1,082	504	2,264	301	1,760	93	19	910,556	3,685	97	96	1	3	163	16	70	28	25	54	1	0	0	0	1	MOJAVE DESERT
160	Pine Mountain/Sespe Condor	1,243	193	2,422	421	2,229	93	16	437,040	1,769	92	79	13	8	246	9	16	19	0	50	5	56	3	0	1	SOUTH COAST
161	Oso Canyon	1,258	946	1,647	137	701	89	17	13,916	56	19	18	1	81	266	16	3	7	0	36	1	0	0	0	3	SOUTH COAST, MOJAVE DESERT, SIERRA NEVADA
162	Shaddow Valley	1,092	285	1,750	295	1,465	94	18	276,011	1,117	99	98	1	1	156	10	11	5	9	97	1	0	0	0	1	MOJAVE DESERT
163	Ivanpah Mountains	1,306	821	1,899	221	1,078	92	21	68,600	278	97	94	2	3	170	5	9	3	15	66	1	0	0	0	1	MOJAVE DESERT
164	Cuddy Creek	1,721	1,599	2,042	87	443	82	30	2,866	12	70	0	70	30	249	8	2	0	0	0	0	0	0	1	1	SOUTH COAST
165		295	56	585	97	529	90	19	25,446	103	13	13	0	87	259	3	6	1	0	23	1	100	1	0	2	SOUTH COAST, CENTRAL COAST
166		851	786	1,100	63	314	94	18	36,500	148	100	99	1	0	155	4	1	1	0	66	1	0	0	1	1	MOJAVE DESERT
167		333	170	563	82	393	90	16	5,765	23	19	19	0	81	255	2	2	1	0	0	0	27	1	0	1	CENTRAL COAST
168	San Ynez Mountains West	231	1	637	118	636	93	16	78,607	318	2	2	0	98	272	22	14	15	0	25	4	100	2	1	2	SOUTH COAST, CENTRAL COAST
169		122	38	294	41	256	72	35	2,945	12	97	97	0	3	255	5	10	2	0	0	0	100	1	0	1	CENTRAL COAST
170		929	882	1,004	21	122	76	28	6,159	25	98	98	0	2	158	0	0	1	0	5	1	0	0	0	1	MOJAVE DESERT
171		959	908	1,018	21	110	88	22	2,251	9	96	96	0	4	159	1	0	1	0	0	0	0	0	0	1	MOJAVE DESERT
172		928	871	1,048	38	177	80	28	5,056	20	99	99	0	1	163	2	0	1	0	0	0	0	0	0	1	MOJAVE DESERT
173	Apache Canyon	1,449	753	2,689	381	1,936	90	22	139,527	565	88	74	14	12	242	6	11	14	0	4	1	4	1	0	2	SOUTH COAST, GREAT CENTRAL VALLEY
174		150	64	323	46	259	71	37	2,475	10	88	84	4	12	258	3	8	4	0	0	0	99	1	0	1	CENTRAL COAST
175		324	204	429	40	225	88	19	6,368	26	0	0	0	100	255	0	1	1	0	0	0	0	0	0	1	CENTRAL COAST
176	Rand Mountains	1,007	911	1,141	44	230	78	32	12,374	50	100	100	0	0	158	0	0	1	0	88	1	0	0	0	1	MOJAVE DESERT
177		1,491	1,012	1,937	197	925	95	14	26,818	109	98	98	0	2	205	13	6	5	0	0	0	0	0	0	2	MOJAVE DESERT, SIERRA NEVADA
178	San Emigdio Mountains	1,006	192	2,275	477	2,083	87	22	186,367	754	86	80	7	14	239	21	7	17	0	2	1	17	1	0	3	SOUTH COAST, SIERRA NEVADA, GREAT CENTRAL VALLEY
179	Tehachapi Mountains	1,060	149	2,068	464	1,919	89	20	147,149	595	81	81	0	19	250	19	9	12	0	65	1	0	0	0	4	SOUTH COAST, MOJAVE DESERT, SIERRA NEVADA, GREAT CENTRAL VALLEY
180		254	167	390	42	223	95	5	5,441	22	0	0	0	100	252	2	2	3	0	35	2	3	1	0	1	CENTRAL COAST
181	Clark Mountain Range	1,217	774	2,399	286	1,625	94	18	117,344	475	99	93	6	1	171	13	45	10	76	22	1	0	0	0	1	MOJAVE DESERT
182		169	130	344	18	214	64	39	2,090	8	100	98	2	0	145	2	0	3	0	0	0	0	0	0	1	MOJAVE DESERT
183	Sidney Peak	839	576	1,438	200	862	82	28	86,495	350	99	99	0	1	164	2	2	10	0	48	1	0	0	0	1	MOJAVE DESERT
184		294	124	692	127	568	74	25	6,346	26	89	89	0	11	247	6	1	2	0	0	0	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
185		195	58	317	47	259	96	9	7,066	29	0	0	0	100	261	1	5	7	0	0	0	18	2	0	1	CENTRAL COAST
186		770	642	1,069	79	427	78	34	9,698	39	100	100	0	0	164	1	0	3	0	91	1	0	0	0	1	MOJAVE DESERT

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
142	1	High Desert Plains and Hills	1	ANTELOPE	4	1	Los Angeles	2	86	12	0	0	1	0	0	0
143	1	Santa Ynez-Sulphur Mountains	1	PITAS POINT	0	1	Ventura	4	93	2	0	0	1	0	0	0
144	4	High Desert Plains and Hills, Mojave Valley-Granite Mountains, Lucerne-Johnson Valleys and Hills, Bullion Mountains-Bristol Lake	3	BESSEMER, LUCERNE LAKE, MOJAVE	95	1	San Bernardino	0	53	0	1	0	0	0	0	46
145	2	Northern Transverse Ranges, Sierra Pelona-Mint Canyon	2	ANTELOPE, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	5	89	2	0	0	4	0	0	0
146	2	Mojave Valley-Granite Mountains, Bullion Mountains-Bristol Lake	1	MOJAVE	79	1	San Bernardino	0	67	0	1	0	0	0	0	31
147	2	Northern Transverse Ranges, Sierra Pelona-Mint Canyon	1	SANTA CLARA - CALLEGUAS	0	1	Los Angeles	5	89	3	1	0	2	0	0	0
148	1	High Desert Plains and Hills	1	MOJAVE	100	1	San Bernardino	0	81	0	0	0	0	0	0	19
149	2	High Desert Plains and Hills, Mojave Valley-Granite Mountains	1	MOJAVE	99	1	San Bernardino	0	60	0	0	0	0	0	0	40
150	2	Northern Transverse Ranges, High Desert Plains and Hills	2	ANTELOPE, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	19	62	17	0	0	1	0	0	0
151	1	High Desert Plains and Hills	2	ANTELOPE, MOJAVE	84	3	San Bernardino, Kern, Los Angeles	0	83	0	0	0	2	0	0	15
152	1	High Desert Plains and Hills	1	MOJAVE	100	1	San Bernardino	0	96	0	2	0	0	0	0	2
153	2	Northern Transverse Ranges, High Desert Plains and Hills	1	ANTELOPE	0	1	Los Angeles	18	49	33	0	0	0	0	0	0
154	6	Mojave Valley-Granite Mountains, Silurian Valley-Devil's Playground, Kingston Range-Valley Wells, Ivanpah Valley, Providence Mountains-Lanfair Valley, Bullion Mountains-Bristol Lake	3	BROADWELL, MOJAVE, ROUTE SIXTY SIX	0	1	San Bernardino	0	54	0	1	0	0	0	0	45
155	3	Santa Ynez Valleys and Hills, Santa Ynez-Sulphur Mountains, San Rafael-Topatopa Mountains	2	SANTA YNEZ, SOUTH COAST	0	1	Santa Barbara	2	95	1	1	0	1	0	0	0
156	3	Northern Transverse Ranges, Sierra Pelona-Mint Canyon, High Desert Plains and Hills	2	ANTELOPE, SANTA CLARA - CALLEGUAS	0	1	Los Angeles	20	69	8	0	0	1	0	0	0
157	1	Santa Ynez-Sulphur Mountains	2	SANTA YNEZ, SOUTH COAST	0	1	Santa Barbara	3	92	1	1	0	2	1	0	0
158	2	Santa Ynez Valleys and Hills, Santa Ynez-Sulphur Mountains	2	SANTA YNEZ, SOUTH COAST	0	1	Santa Barbara	4	93	1	1	0	1	1	0	0
159	5	Silurian Valley-Devil's Playground, Ivanpah Valley, Providence Mountains-Lanfair Valley, Piute Valley-Sacramento Mountains, Bullion Mountains-Bristol Lake	5	HOMER, IVANPAH, MOJAVE, ROUTE SIXTY SIX, WARD	10	1	San Bernardino	0	76	0	0	0	0	0	0	23
160	5	Santa Ynez-Sulphur Mountains, Oxnard Plain-Santa Paula Valley, San Rafael-Topatopa Mountains, Northern Transverse Ranges, Sierra Pelona-Mint Canyon	4	GRAPEVINE, SANTA CLARA - CALLEGUAS, SANTA MARIA, VENTURA RIVER	0	3	Kern, Ventura, Los Angeles	50	40	9	1	0	1	0	0	0
161	4	Eastern Slopes, San Emigdio Mountains, Northern Transverse Ranges, High Desert Plains and Hills	3	ANTELOPE, GRAPEVINE, SANTA CLARA - CALLEGUAS	0	2	Kern, Los Angeles	29	19	51	0	0	1	0	0	0
162	3	Silurian Valley-Devil's Playground, Kingston Range-Valley Wells, Ivanpah Valley	3	AMARGOSA, IVANPAH, MOJAVE	0	1	San Bernardino	0	72	0	0	0	0	0	0	27
163	2	Kingston Range-Valley Wells, Ivanpah Valley	2	AMARGOSA, IVANPAH	0	1	San Bernardino	0	74	0	0	0	0	0	0	26
164	2	San Emigdio Mountains, Northern Transverse Ranges	1	GRAPEVINE	0	2	Kern, Ventura	86	1	7	0	0	3	1	2	0
165	1	Santa Ynez-Sulphur Mountains	2	SANTA YNEZ, SOUTH COAST	0	1	Santa Barbara	4	78	14	1	0	2	0	0	0
166	2	Ivanpah Valley, Hualapai Mountains Coniferous Forest	1	IVANPAH	99	1	San Bernardino	0	73	0	0	0	0	0	0	27
167	1	Santa Ynez Valleys and Hills	2	SAN ANTONIO, SANTA YNEZ	0	1	Santa Barbara	6	78	11	0	0	4	0	0	0
168	1	Santa Ynez-Sulphur Mountains	2	SANTA YNEZ, SOUTH COAST	0	1	Santa Barbara	4	81	10	1	0	4	1	0	0
169	1	Santa Ynez Valleys and Hills	1	SANTA YNEZ	0	1	Santa Barbara	0	78	1	1	0	4	15	0	0
170	1	High Desert Plains and Hills	1	ANTELOPE	84	1	Kern	0	95	0	0	0	0	0	0	4
171	1	High Desert Plains and Hills	1	ANTELOPE	86	1	Kern	0	98	0	0	0	0	0	0	2
172	1	High Desert Plains and Hills	1	FREMONT	100	1	Kern	0	80	0	0	0	0	0	0	20
173	3	Caliente Range-Cuyama Valley, Temblor Range, Northern Transverse Ranges	4	CARRIZO PLAIN, GRAPEVINE, SANTA CLARA - CALLEGUAS, SANTA MARIA	0	4	Kern, San Luis Obispo, Santa Barbara, Ventura	61	16	21	0	0	1	0	0	0
174	1	Santa Ynez Valleys and Hills	2	SAN ANTONIO, SANTA YNEZ	0	1	Santa Barbara	1	81	3	1	0	7	7	0	0
175	1	Santa Ynez Valleys and Hills	2	SAN ANTONIO, SANTA MARIA	0	1	Santa Barbara	2	55	41	1	0	1	0	0	0
176	2	High Desert Plains and Hills, Mojave Valley-Granite Mountains	2	ANTELOPE, CUDDEBACK	74	2	San Bernardino, Kern	0	90	0	0	0	1	0	0	9
177	3	Eastern Slopes, Tehachapi-Piute Mountains, High Desert Plains and Hills	2	FREMONT, GRAPEVINE	26	1	Kern	32	67	0	1	0	0	0	0	0
178	6	South Valley Alluvium and Basins, Elk Hills and South Valley Terraces, San Emigdio Mountains, Caliente Range-Cuyama Valley, Temblor Range, Northern Transverse Ranges	4	CARRIZO PLAIN, GRAPEVINE, SANTA MARIA, SOUTH VALLEY FLOOR	0	2	Kern, Ventura	34	18	45	0	0	2	0	0	1
179	7	South Valley Alluvium and Basins, Elk Hills and South Valley Terraces, Eastern Slopes, Tehachapi-Piute Mountains, Southern Granitic Foothills, San Emigdio Mountains, High Desert Plains and Hills	3	ANTELOPE, GRAPEVINE, SOUTH VALLEY FLOOR	0	2	Kern, Los Angeles	26	42	29	1	0	1	0	1	0
180	1	Santa Ynez Valleys and Hills	2	SAN ANTONIO, SANTA MARIA	0	1	Santa Barbara	2	82	7	3	0	3	3	0	0
181	3	Amargosa Desert-Pahrump Valley, Kingston Range-Valley Wells, Ivanpah Valley	3	AMARGOSA, IVANPAH, MESQUITE	15	1	San Bernardino	2	63	0	1	0	0	0	0	34
182	1	Silurian Valley-Devil's Playground	1	AMARGOSA	97	1	San Bernardino	0	59	0	13	0	1	0	0	26
183	2	High Desert Plains and Hills, Mojave Valley-Granite Mountains	3	ANTELOPE, CUDDEBACK, FREMONT	91	1	Kern	0	74	0	0	0	0	1	0	24
184	2	South Valley Alluvium and Basins, Southern Granitic Foothills	2	GRAPEVINE, SOUTH VALLEY FLOOR	0	1	Kern	0	19	75	0	0	1	5	0	0
185	1	Santa Ynez Valleys and Hills	1	SAN ANTONIO	0	1	Santa Barbara	0	93	5	0	0	1	0	0	0
186	2	High Desert Plains and Hills, Mojave Valley-Granite Mountains	1	FREMONT	99	1	Kern	0	71	0	0	0	1	0	0	29

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
187	Mesquite Mountains	1,072	791	1,428	125	637	96	14	30,031	122	100	99	1	0	155	5	1	1	62	9	1	0	0	0	1	MOJAVE DESERT
188		971	837	1,177	65	340	85	28	11,181	45	100	100	0	0	151	13	0	3	0	72	1	0	0	0	1	MOJAVE DESERT
189		877	405	1,399	224	994	68	22	3,019	12	91	91	0	9	253	5	0	0	0	0	0	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
190	Calico Mountains	844	320	1,651	202	1,331	91	21	1,004,928	4,067	95	84	11	5	152	11	14	16	0	89	1	0	0	0	1	MOJAVE DESERT
191		471	266	796	128	530	74	18	2,196	9	0	0	0	100	254	2	0	0	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
192		712	615	919	57	304	100	0	3,442	14	100	94	5	0	138	0	0	2	0	0	0	0	0	0	1	MOJAVE DESERT
193		381	235	543	75	308	84	21	5,543	22	59	59	0	41	254	1	6	4	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
194		490	268	963	138	695	87	21	7,170	29	29	29	0	71	253	3	4	1	0	0	0	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
195		458	124	914	141	790	91	17	25,288	102	0	0	0	100	253	14	0	2	0	0	0	35	1	0	1	CENTRAL COAST
196		1,241	779	1,724	170	945	96	4	5,621	23	74	71	3	26	232	16	0	2	99	0	0	0	0	0	1	SIERRA NEVADA
197		548	509	691	33	182	87	25	4,055	16	99	96	3	1	140	1	0	2	0	0	0	0	0	0	1	MOJAVE DESERT
198		95	89	171	13	82	52	37	5,888	24	74	73	0	26	200	2	3	14	96	0	0	68	1	0	1	GREAT CENTRAL VALLEY
199	Sierra Madre Mountains	957	31	2,082	365	2,051	96	13	805,948	3,262	82	73	9	18	247	16	30	23	0	20	5	38	3	0	3	SOUTH COAST, CENTRAL COAST, GREAT CENTRAL VALLEY
200	Ten Section Oil Field	99	96	102	1	6	77	18	2,288	9	0	0	0	100	196	1	1	3	0	0	0	100	1	0	1	GREAT CENTRAL VALLEY
201	El Paso Mountains	988	590	1,593	163	1,003	90	23	46,959	190	100	99	1	0	166	6	4	11	0	0	0	0	0	0	1	MOJAVE DESERT
202	Casmalia Hills	138	0	501	123	501	89	23	33,455	135	22	22	0	78	290	25	15	22	0	17	2	100	4	5	1	CENTRAL COAST
203	Kingston Range/ Shadow Valley	863	203	2,224	336	2,021	96	16	365,414	1,479	100	82	17	0	161	12	18	22	68	26	2	0	0	0	1	MOJAVE DESERT
204	California Valley/ Kingston Range	947	446	1,871	215	1,425	97	11	122,251	495	99	87	12	1	157	14	19	7	33	0	0	0	0	0	1	MOJAVE DESERT
205		409	404	487	8	83	86	27	3,022	12	98	57	41	2	156	2	3	7	99	68	1	0	0	7	1	MOJAVE DESERT
206		914	855	967	20	112	98	9	3,651	15	85	0	85	15	172	3	0	2	100	0	0	0	0	0	1	MOJAVE DESERT
207		14	1	42	9	41	50	23	2,118	9	99	96	3	1	302	20	7	8	0	89	1	50	3	24	1	CENTRAL COAST
208		298	74	540	79	466	92	12	6,588	27	0	0	0	100	269	7	1	1	0	0	0	84	1	0	1	CENTRAL COAST
209	Lucas Creek	995	190	2,079	451	1,889	87	24	50,621	205	71	54	16	29	254	10	11	15	76	0	0	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
210	Elk Hills	219	79	470	104	391	75	32	55,189	223	85	48	37	15	198	3	9	17	35	0	0	99	1	0	1	GREAT CENTRAL VALLEY
211	Carrizo Plain/ Temblor Range	740	363	1,317	160	954	89	22	163,850	663	88	82	7	12	215	6	11	18	0	0	2	100	2	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
212		284	192	378	47	186	90	17	2,365	10	0	0	0	100	212	1	0	1	0	0	0	0	0	4	1	GREAT CENTRAL VALLEY
213		627	594	678	24	84	83	27	4,038	16	0	0	0	100	216	3	2	4	0	13	2	100	2	0	1	GREAT CENTRAL VALLEY
214	Piute Mountains/ Scodie Mountains	1,373	632	2,460	337	1,828	89	22	332,205	1,344	97	91	6	3	204	26	26	19	41	0	0	0	0	0	2	MOJAVE DESERT, SIERRA NEVADA
215	Poso Creek	259	172	352	39	180	94	14	3,064	12	0	0	0	100	209	0	0	1	0	0	0	0	0	1	1	GREAT CENTRAL VALLEY
216		327	89	511	75	422	71	11	2,051	8	93	93	0	7	288	23	3	0	0	0	0	0	0	1	1	CENTRAL COAST
217	McKittrick Valley	122	75	247	41	172	74	36	21,967	89	98	98	0	2	196	4	6	12	0	0	0	82	1	0	1	GREAT CENTRAL VALLEY
218		444	329	631	68	302	90	19	3,842	16	0	0	0	100	244	7	2	2	0	61	1	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
219	Nopah Range	873	408	1,935	278	1,527	98	12	122,187	494	100	91	8	0	141	7	8	9	8	1	1	0	0	1	1	MOJAVE DESERT
220	Sequoia National Forest/ Greenhorn Mountains	932	138	1,982	392	1,844	89	24	119,430	483	38	24	14	62	252	16	17	16	76	10	1	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
221		466	363	659	59	296	81	22	5,881	24	91	90	1	9	240	2	1	2	0	0	0	0	0	0	1	CENTRAL COAST
222		856	495	1,134	134	639	95	14	16,035	65	0	0	0	100	245	3	2	1	6	100	1	0	0	0	1	SIERRA NEVADA
223	Five Dog Creek	292	218	365	29	147	88	21	4,900	20	0	0	0	100	210	2	0	2	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
224		209	0	524	113	524	67	44	10,156	41	81	77	3	19	298	26	16	9	100	9	2	5	2	2	1	CENTRAL COAST
225		517	430	598	31	168	92	16	2,523	10	0	0	0	100	221	7	2	0	0	9	1	0	0	0	2	CENTRAL COAST GREAT CENTRAL VALLEY
226		399	296	569	62	273	76	23	2,340	9	91	91	0	9	242	12	2	1	0	0	0	0	1	0	1	CENTRAL COAST
227		74	71	86	3	15	63	45	8,860	36	34	34	0	66	193	2	4	5	0	0	0	0	0	15	1	GREAT CENTRAL VALLEY
228		208	168	252	16	84	87	23	3,490	14	0	0	0	100	206	1	0	3	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
229	La Panza Range	677	115	1,553	195	1,438	93	18	483,280	1,956	71	61	10	29	233	12	31	27	0	6	5	29	3	0	3	SOUTH COAST, CENTRAL COAST, GREAT CENTRAL VALLEY
230	Gordon Gulch/ Sand Canyon	363	196	669	103	473	88	22	18,148	73	0	0	0	100	236	16	2	1	0	49	1	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
231		173	151	192	10	41	81	31	4,462	18	0	0	0	100	191	0	0	3	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
187	2	Amargosa Desert-Pahrump Valley, Kingston Range-Valley Wells	2	AMARGOSA, MESQUITE	9	1	San Bernardino	0	57	0	0	0	0	0	0	43
188	2	High Desert Plains and Hills, Mojave Valley-Granite Mountains	1	FREMONT	98	2	San Bernardino, Kern	0	90	0	0	0	0	0	0	10
189	3	South Valley Alluvium and Basins, Tehachapi-Piute Mountains, Southern Granitic Foothills	2	GRAPEVINE, SOUTH VALLEY FLOOR	0	1	Kern	2	83	13	1	0	1	0	0	0
190	4	Searles Valley-Owlshead Mountains, High Desert Plains and Hills, Mojave Valley-Granite Mountains, Silurian Valley-Devil's Playground	10	ANTELOPE, BALLARAT, BICYCLE, COYOTE, CUDDEBACK, FREMONT, GOLDSTONE, MOJAVE, SUPERIOR, TRONA	71	1	San Bernardino	0	73	0	1	0	0	0	0	26
191	3	Hardpan Terraces, South Valley Alluvium and Basins, Southern Granitic Foothills	2	GRAPEVINE, SOUTH VALLEY FLOOR	0	1	Kern	0	17	83	0	0	0	0	0	0
192	2	Searles Valley-Owlshead Mountains, Mojave Valley-Granite Mountains	1	TRONA	0	1	San Bernardino	0	70	0	1	0	0	0	0	29
193	3	Hardpan Terraces, South Valley Alluvium and Basins, Southern Granitic Foothills	2	GRAPEVINE, SOUTH VALLEY FLOOR	0	1	Kern	0	4	94	0	0	1	1	0	0
194	2	Hardpan Terraces, Southern Granitic Foothills	2	GRAPEVINE, SOUTH VALLEY FLOOR	0	1	Kern	0	14	84	1	0	0	0	0	0
195	3	South Costal Santa Lucia Range, Santa Maria Valley, Interior Santa Lucia Range	1	SANTA MARIA	0	2	San Luis Obispo, Santa Barbara	17	72	8	1	0	1	1	1	0
196	1	Tehachapi-Piute Mountains	1	GRAPEVINE	0	1	Kern	27	65	6	1	0	0	0	0	0
197	1	Searles Valley-Owlshead Mountains	1	TRONA	0	1	San Bernardino	0	26	0	0	0	0	0	0	74
198	2	South Valley Alluvium and Basins, Elk Hills and South Valley Terraces	1	SOUTH VALLEY FLOOR	0	1	Kern	0	7	61	0	15	9	4	1	2
199	7	Santa Maria Valley, Santa Ynez Valleys and Hills, Santa Ynez-Sulphur Mountains, Interior Santa Lucia Range, Caliente Range-Cuyama Valley, San Rafael-Topatopa Mountains, Northern Transverse Ranges	6	PITAS POINT, SANTA CLARA - CALLEGUAS, SANTA MARIA, SANTA YNEZ, SOUTH COAST, VENTURA RIVER	0	3	San Luis Obispo, Santa Barbara, Ventura	44	46	8	1	0	1	0	0	0
200	1	South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	1	Kern	0	0	98	0	0	1	1	0	0
201	2	Searles Valley-Owlshead Mountains, High Desert Plains and Hills	2	FREMONT, INDIAN WELLS	0	1	Kern	0	60	0	2	0	0	0	0	38
202	2	Santa Maria Valley, Santa Ynez Valleys and Hills	2	SAN ANTONIO, SANTA MARIA	0	2	San Luis Obispo, Santa Barbara	1	60	11	2	0	4	0	0	22
203	4	Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley, Silurian Valley-Devil's Playground, Kingston Range-Valley Wells	3	AMARGOSA, MESQUITE, MOJAVE	27	2	Inyo, San Bernardino	1	64	0	2	0	0	0	0	33
204	3	Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley, Kingston Range-Valley Wells	3	AMARGOSA, MESQUITE, PAHRUMP	16	2	Inyo, San Bernardino	0	66	0	0	0	0	0	0	34
205	1	Funeral Mountains-Greenwater Valley	1	AMARGOSA	72	1	Inyo	0	31	0	5	0	0	0	0	64
206	1	High Desert Plains and Hills	1	INDIAN WELLS	0	1	Kern	0	97	0	0	0	0	0	0	3
207	1	Santa Maria Valley	1	ESTERO BAY	0	1	San Luis Obispo	2	25	2	12	5	2	8	0	45
208	2	South Costal Santa Lucia Range, Interior Santa Lucia Range	2	ESTERO BAY, SANTA MARIA	0	1	San Luis Obispo	6	84	7	0	0	1	0	1	0
209	3	Hardpan Terraces, Tehachapi-Piute Mountains, Southern Granitic Foothills	3	GRAPEVINE, KERN RIVER, SOUTH VALLEY FLOOR	0	1	Kern	33	39	24	2	0	0	0	0	2
210	3	Antelope Plain, South Valley Alluvium and Basins, Elk Hills and South Valley Terraces	1	SOUTH VALLEY FLOOR	40	1	Kern	0	34	55	0	0	8	1	1	1
211	4	Elk Hills and South Valley Terraces, Carrizo Plain, Caliente Range-Cuyama Valley, Temblor Range	5	CARRIZO PLAIN, FELLOWS, GRAPEVINE, SOUTH VALLEY FLOOR, TEMBLOR	75	2	Kern, San Luis Obispo	9	36	45	0	1	3	0	0	6
212	1	Hardpan Terraces	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Kern	0	6	91	1	0	2	0	0	0
213	1	Carrizo Plain	1	CARRIZO PLAIN	0	1	San Luis Obispo	0	38	56	0	0	2	1	3	0
214	5	Eastern Slopes, Tehachapi-Piute Mountains, Kern Plateau, Southern Granitic Foothills, High Desert Plains and Hills	4	FREMONT, GRAPEVINE, INDIAN WELLS, KERN RIVER	57	1	Kern	20	77	0	1	0	0	0	0	1
215	1	Hardpan Terraces	1	SOUTH VALLEY FLOOR	0	1	Kern	0	1	98	1	0	1	0	0	0
216	1	South Costal Santa Lucia Range	1	ESTERO BAY	0	1	San Luis Obispo	17	82	0	0	0	0	0	0	0
217	2	Antelope Plain, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	98	1	Kern	0	14	36	0	0	3	35	4	8
218	2	Hardpan Terraces, Southern Granitic Foothills	1	SOUTHERN SIERRA	0	1	Kern	0	24	76	0	0	0	0	0	0
219	2	Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley	2	AMARGOSA, PAHRUMP	3	1	Inyo	0	56	0	1	0	0	0	0	43
220	3	Hardpan Terraces, Lower Batholith, Southern Granitic Foothills	3	KERN RIVER, SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Kern	29	44	24	2	0	0	0	0	0
221	1	Interior Santa Lucia Range	1	SALINAS	0	1	San Luis Obispo	27	55	5	5	5	3	0	0	0
222	1	Southern Granitic Foothills	1	SOUTHERN SIERRA	0	1	Kern	8	87	2	3	0	0	0	0	0
223	1	Hardpan Terraces	1	SOUTH VALLEY FLOOR	0	1	Kern	0	1	97	0	0	2	0	0	0
224	1	South Costal Santa Lucia Range	1	ESTERO BAY	0	1	San Luis Obispo	4	85	2	0	0	5	0	0	3
225	1	Paso Robles Hills and Valleys	1	ESTRELLA RIVER	0	1	San Luis Obispo	3	39	57	0	0	1	0	0	0
226	1	Interior Santa Lucia Range	1	SALINAS	91	1	San Luis Obispo	31	64	2	2	0	1	0	0	0
227	1	South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	1	Kern	0	4	5	2	0	3	61	26	0
228	1	Hardpan Terraces	1	SOUTH VALLEY FLOOR	0	1	Kern	0	1	88	0	0	4	6	1	0
229	5	South Costal Santa Lucia Range, Interior Santa Lucia Range, Paso Robles Hills and Valleys, Carrizo Plain, Caliente Range-Cuyama Valley	5	CARRIZO PLAIN, ESTERO BAY, ESTRELLA RIVER, SALINAS, SANTA MARIA	27	3	Kern, San Luis Obispo, Santa Barbara	31	36	28	0	0	1	0	1	2
230	2	Hardpan Terraces, Southern Granitic Foothills	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Kern	0	18	81	0	0	0	0	0	0
231	1	Antelope Plain	1	SOUTH VALLEY FLOOR	0	1	Kern	0	4	82	0	0	2	10	0	2

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
232	Resting Spring Range	869	520	1,594	204	1,074	96	16	81,324	329	100	99	1	0	138	1	3	2	0	0	0	0	0	1	1	MOJAVE DESERT
233		478	309	793	81	484	98	9	2,679	11	76	0	76	24	270	2	6	0	0	0	0	100	1	0	1	CENTRAL COAST
234		142	124	180	12	56	93	20	9,649	39	0	0	0	100	191	1	0	4	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
235		68	65	77	2	12	95	14	20,336	82	18	18	0	82	196	1	7	10	0	0	0	0	0	8	1	GREAT CENTRAL VALLEY
236		464	153	1,465	306	1,312	89	22	48,518	196	1	0	1	99	236	17	5	3	0	44	1	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
237		442	351	602	43	251	86	24	20,749	84	0	0	0	100	214	5	4	5	0	0	0	11	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
238	Kern National Wildlife Refuge	68	64	75	2	11	94	17	32,737	132	56	56	0	44	198	2	7	19	0	0	0	0	0	39	1	GREAT CENTRAL VALLEY
239		233	182	316	26	134	83	26	4,214	17	0	0	0	100	243	12	1	1	0	0	0	0	0	1	1	GREAT CENTRAL VALLEY
240		391	294	514	36	220	91	17	16,073	65	0	0	0	100	213	2	1	1	0	0	0	17	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
241	Allensworth	73	64	81	4	17	55	39	5,459	22	67	67	0	33	196	1	3	9	0	4	1	24	1	65	1	GREAT CENTRAL VALLEY
242	San Geronimo	162	7	488	80	481	92	13	15,309	62	0	0	0	100	275	16	4	4	0	0	0	100	1	0	1	CENTRAL COAST
243		65	63	71	2	8	89	20	18,836	76	3	1	2	97	197	2	0	8	0	0	0	0	0	6	1	GREAT CENTRAL VALLEY
244		540	330	785	92	455	88	21	95,439	386	0	0	0	100	210	6	8	10	0	3	1	52	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
245	Allensworth	63	63	66	0	3	54	42	3,272	13	37	37	0	63	203	2	1	4	0	0	0	0	0	8	1	GREAT CENTRAL VALLEY
246		506	153	1,194	227	1,041	94	15	244,363	989	7	3	4	93	207	11	17	15	0	4	2	67	2	0	3	CENTRAL COAST, CENTRAL COAST, GREAT CENTRAL VALLEY
247	Santa Rosa Creek	175	40	427	67	387	93	12	4,436	18	0	0	0	100	277	21	3	4	0	0	0	100	2	0	1	CENTRAL COAST
248	Las Colinas/ South Dome	156	113	214	17	101	96	12	9,100	37	0	0	0	100	196	7	0	4	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
249	Pixley National Wildlife Refuge	68	61	76	3	15	75	28	5,715	23	93	93	0	7	202	2	3	9	0	84	1	84	1	76	1	GREAT CENTRAL VALLEY
250	Bluestone Ridge	412	177	952	178	775	94	18	33,696	136	8	0	8	92	205	9	9	7	0	3	1	3	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
251	Sand Ridge	62	58	74	3	16	93	18	19,628	79	0	0	0	100	199	4	3	8	0	0	0	0	0	14	1	GREAT CENTRAL VALLEY
252	Tennessee Ridge	311	170	733	107	563	88	15	17,134	69	1	0	1	99	253	6	5	3	0	1	1	0	0	1	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
253	Death Valley/ Black Mountains/ Amargosa Range	739	-82	1,928	530	2,010	95	19	444,103	1,797	100	100	0	0	145	6	10	6	0	0	0	0	0	1	1	MOJAVE DESERT
254	Homeland Canal	61	58	64	1	6	4	16	7,893	32	92	92	0	8	197	3	0	3	0	0	0	0	0	3	1	GREAT CENTRAL VALLEY
255	Kettleman Hills/ Las Alturas	167	119	225	21	106	95	14	2,130	9	0	0	0	100	202	0	0	2	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
256	Dudley Ridge	63	59	71	3	12	94	15	4,114	17	0	0	0	100	206	11	0	1	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
257		389	249	636	71	387	75	20	7,722	31	96	96	0	4	244	12	1	0	0	0	0	0	0	0	1	CENTRAL COAST
258		1,193	471	2,362	303	1,891	96	16	95,386	386	100	97	3	0	155	8	1	12	0	1	1	0	0	0	1	MOJAVE DESERT
259		1,133	1,106	1,195	17	89	55	37	2,191	9	99	88	11	1	234	17	1	4	0	0	0	0	0	0	2	MOJAVE DESERT, SIERRA NEVADA
260	Silver Mountain/ Rose Valley	1,520	1,015	2,307	325	1,292	95	17	82,924	336	99	75	23	1	181	23	5	7	30	0	0	0	0	0	2	MOJAVE DESERT, SIERRA NEVADA
261	Frazier Valley/ Rocky Hill	257	139	539	96	400	75	20	6,059	25	2	0	2	98	256	4	4	2	0	74	1	0	0	2	1	GREAT CENTRAL VALLEY
262		366	244	659	75	415	85	20	4,229	17	94	94	0	6	274	3	0	0	0	0	0	0	0	0	1	CENTRAL COAST
263	Kettleman Hills/ La Bajada	204	127	300	38	173	81	28	4,432	18	35	35	0	65	186	1	1	3	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
264		1,278	468	2,286	514	1,818	94	21	80,138	324	100	100	0	0	156	11	11	4	0	0	0	0	0	0	1	MOJAVE DESERT
265	Pixley National Wildlife Refuge	66	61	70	1	9	73	32	8,846	36	80	80	0	20	199	1	0	7	0	79	1	79	1	81	1	GREAT CENTRAL VALLEY
266	Gholame Hills	558	336	873	110	537	90	21	50,611	205	3	3	0	97	209	4	3	4	0	0	0	96	1	0	1	CENTRAL COAST
267	Inyo Mountains	1,763	1,145	2,356	284	1,211	96	15	32,493	131	100	99	1	0	175	23	1	0	0	0	0	0	0	0	2	MOJAVE DESERT, SIERRA NEVADA
268		352	195	596	83	401	93	11	6,257	25	8	0	7	92	235	2	0	0	0	0	0	0	0	0	1	CENTRAL COAST
269	Death Valley/ Panamint Range	770	-81	3,361	648	3,442	97	13	1,087,587	4,401	100	100	0	0	162	18	41	23	0	0	0	0	0	0	1	MOJAVE DESERT
270	Yokohl Valley/ Oat Canyon	300	149	766	97	617	86	16	23,214	94	0	0	0	100	254	5	2	1	0	76	1	0	1	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
271		316	238	380	28	142	96	9	3,758	15	28	0	28	72	238	0	6	0	0	0	0	0	0	0	1	CENTRAL COAST
272		388	266	571	54	305	93	11	4,665	19	4	0	4	96	259	17	2	1	0	0	0	0	0	0	1	CENTRAL COAST
273	Kettleman Hills	277	157	408	46	251	65	39	16,839	68	75	75	0	25	188	5	1	7	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
274	Cross Creek	66	65	70	1	5	90	14	2,907	12	0	0	0	100	197	0	0	1	0	0	0	0	0	77	1	GREAT CENTRAL VALLEY
275		338	181	524	76	343	88	12	2,718	11	0	0	0	100	238	13	1	0	0	0	0	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
276	Death Valley	201	-51	670	152	721	81	33	14,787	60	100	100	0	0	148	3	0	0	0	0	0	0	0	0	1	MOJAVE DESERT
277	Kettleman Hills/ North Dome	276	182	402	43	220	48	40	10,167	41	77	77	0	23	193	8	1	6	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
278	Owens Valley	1,090	1,076	1,142	8	66	93	22	81,169	328	100	99	1	0	224	14	3	16	0	0	0	0	0	4	2	MOJAVE DESERT, SIERRA NEVADA
279	Funeral Mountains	850	-65	2,031	420	2,096	97	15	263,324	1,066	100	99	0	0	142	7	27	12	0	0	0	0	0	0	1	MOJAVE DESERT
280		1,262	1,119	1,441	114	322	45	33	4,406	18	99	95	4	1	240	6	4	8	0	0	0	0	0	18	1	SIERRA NEVADA

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
232	2	Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley	2	AMARGOSA, PAHRUMP	0	1	Inyo	0	52	0	1	0	0	0	0	47
233	2	South Costal Santa Lucia Range, Interior Santa Lucia Range	2	ESTERO BAY, SALINAS	0	1	San Luis Obispo	1	93	5	1	0	0	0	0	0
234	1	Antelope Plain	1	SOUTH VALLEY FLOOR	0	1	Kern	0	1	80	0	0	6	10	1	3
235	1	South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	1	Kern	0	0	1	0	0	3	15	81	0
236	3	Hardpan Terraces, Lower Granitic Foothills, Southern Granitic Foothills	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	2	Tulare, Kern	7	28	60	1	0	1	2	1	0
237	1	Paso Robles Hills and Valleys	2	ESTRELLA RIVER, SALINAS	0	1	San Luis Obispo	1	16	79	0	0	1	1	2	0
238	2	Antelope Plain, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	2	Kings, Kern	0	3	5	14	1	4	13	60	0
239	2	Hardpan Terraces, Lower Granitic Foothills	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Tulare	0	3	87	0	0	1	9	0	0
240	1	Paso Robles Hills and Valleys	2	ESTRELLA RIVER, SALINAS	0	1	San Luis Obispo	3	27	69	0	0	1	0	0	0
241	1	South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	1	Tulare	0	0	55	0	0	2	21	22	0
242	1	South Costal Santa Lucia Range	1	ESTERO BAY	0	1	San Luis Obispo	1	55	42	1	0	0	0	0	0
243	2	Tulare Basin, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	3	Tulare, Kings, Kern	0	0	1	0	0	1	43	54	0
244	2	Paso Robles Hills and Valleys, Carrizo Plain	3	CARRIZO PLAIN, ESTRELLA RIVER, TEMBLOR	0	2	Kern, San Luis Obispo	3	36	56	0	0	2	1	1	1
245	2	Tulare Basin, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	1	Tulare	0	0	11	0	0	3	55	31	0
246	6	Antelope Plain, Elk Hills and South Valley Terraces, Eastern Hills, Paso Robles Hills and Valleys, Carrizo Plain, Temblor Range	4	CARRIZO PLAIN, ESTRELLA RIVER, SOUTH VALLEY FLOOR, TEMBLOR	3	2	Kern, San Luis Obispo	4	26	58	0	0	4	1	2	4
247	1	South Costal Santa Lucia Range	1	ESTERO BAY	0	1	San Luis Obispo	1	37	60	1	0	0	0	0	0
248	2	Antelope Plain, Kettleman Hills and Valleys	1	SOUTH VALLEY FLOOR	0	2	Kings, Kern	0	0	91	0	0	5	4	0	1
249	3	Granitic Alluvial Fans and Terraces, Tulare Basin, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	1	Tulare	0	1	36	2	0	2	12	48	0
250	3	Antelope Plain, Eastern Hills, Kettleman Hills and Valleys	4	ESTRELLA RIVER, SOUTH VALLEY FLOOR, SUNFLOWER VALLEY, TEMBLOR	0	3	Kings, Kern, San Luis Obispo	4	10	80	0	0	2	1	1	0
251	2	Tulare Basin, South Valley Alluvium and Basins	1	SOUTH VALLEY FLOOR	0	2	Kings Kern	0	0	1	0	0	2	66	30	0
252	2	Hardpan Terraces, Lower Granitic Foothills	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Tulare	1	7	88	1	0	1	1	0	3
253	3	Death Valley, Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley	1	AMARGOSA	0	1	Inyo	0	39	0	2	0	0	0	0	60
254	1	Tulare Basin	1	SOUTH VALLEY FLOOR	0	2	Tulare, Kings	0	0	9	1	1	3	81	6	0
255	1	Kettleman Hills and Valleys	1	SOUTH VALLEY FLOOR	0	1	Kings	0	0	98	0	0	1	0	0	0
256	3	Tulare Basin, South Valley Alluvium and Basins, Kettleman Hills and Valleys	1	SOUTH VALLEY FLOOR	0	1	Kings	0	0	1	1	0	0	39	59	0
257	2	South Costal Santa Lucia Range, Interior Santa Lucia Range	1	SALINAS	0	1	San Luis Obispo	21	55	22	0	0	1	0	0	0
258	3	Panamint Valley, Searles Valley-Owlshead Mountains, Cosa-Argus Ranges	2	BALLARAT, TRONA	10	1	Inyo	0	24	0	2	0	0	0	0	74
259	1	Owens Valley	1	OWENS	0	1	Inyo	0	93	0	1	0	6	0	0	0
260	2	Owens Valley, Cosa-Argus Ranges	3	INDIAN WELLS, OWENS, UPPER CACTUS	0	1	Inyo	12	40	0	5	0	0	0	0	42
261	2	Hardpan Terraces, Lower Granitic Foothills	2	SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Tulare	0	10	84	0	0	0	4	0	0
262	2	South Costal Santa Lucia Range, Interior Santa Lucia Range	1	SALINAS	0	1	San Luis Obispo	16	70	12	1	0	1	0	0	0
263	1	Kettleman Hills and Valleys	1	SOUTH VALLEY FLOOR	35	1	Kings	0	0	94	0	0	5	0	0	0
264	4	Death Valley, Panamint Valley, Saline Valley-Cottonwood Mountains, Panamint Range	2	AMARGOSA, BALLARAT	0	1	Inyo	6	37	0	1	0	0	0	0	57
265	2	Granitic Alluvial Fans and Terraces, Tulare Basin	1	SOUTH VALLEY FLOOR	0	1	Tulare	0	3	40	1	0	2	12	41	0
266	4	Diablo Range, Eastern Hills, Gabilan Range, Paso Robles Hills and Valleys	2	ESTRELLA RIVER, SALINAS	0	2	Monterey, San Luis Obispo	34	18	47	0	0	1	0	0	0
267	3	Owens Valley, Inyo Mountains, Cosa-Argus Ranges	2	BALLARAT, OWENS	0	1	Inyo	14	31	0	0	0	0	0	0	56
268	2	Interior Santa Lucia Range, Paso Robles Hills and Valleys	1	SALINAS	0	1	Monterey	17	58	20	1	1	1	1	1	0
269	8	Death Valley, Funeral Mountains-Greenwater Valley, Panamint Valley, Searles Valley-Owlshead Mountains, Mojave Valley-Granite Mountains, Silurian Valley-Devil's Playground, Saline Valley-Cottonwood Mountains, Panamint Range	5	AMARGOSA, BALLARAT, LEACH, OWLSHEAD, TRONA	0	2	Inyo, San Bernardino	4	32	0	3	0	0	0	0	61
270	2	Hardpan Terraces, Lower Granitic Foothills	3	KAWEAH RIVER, SOUTH VALLEY FLOOR, SOUTHERN SIERRA	0	1	Tulare	1	16	82	0	0	0	1	0	0
271	1	Interior Santa Lucia Range	1	SALINAS	0	1	Monterey	9	48	40	0	0	3	0	0	0
272	1	Interior Santa Lucia Range	1	SALINAS	0	1	Monterey	27	51	19	0	0	3	0	0	0
273	1	Kettleman Hills and Valleys	1	SOUTH VALLEY FLOOR	75	1	Kings	0	0	88	0	0	11	1	0	0
274	2	Granitic Alluvial Fans and Terraces, Tulare Basin	1	SOUTH VALLEY FLOOR	0	1	Kings	0	0	83	0	0	0	4	12	0
275	2	Hardpan Terraces, Lower Granitic Foothills	1	KAWEAH RIVER	0	1	Tulare	0	12	88	0	0	0	0	0	0
276	1	Death Valley	1	AMARGOSA	0	1	Inyo	0	40	0	17	0	0	0	0	43
277	2	Panoche and Cantua Fans and Basins, Kettleman Hills and Valleys	1	SOUTH VALLEY FLOOR	58	2	Fresno, Kings	0	1	84	0	0	12	3	0	0
278	1	Owens Valley	1	OWENS	0	1	Inyo	0	20	0	11	2	0	0	0	66
279	4	Death Valley, Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley, Grapevine Mountains	1	AMARGOSA	0	1	Inyo	0	42	0	4	0	0	0	0	54
280	1	Owens Valley	1	OWENS	0	1	Inyo	0	46	0	26	1	6	0	0	21

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
281	Weferling Canyon	447	182	734	102	552	89	18	16,295	66	28	0	28	72	230	2	5	0	0	0	0	0	0	0	1	CENTRAL COAST
282	Anticline Ridge	196	153	281	29	128	57	40	4,900	20	64	64	0	36	219	3	1	6	0	0	0	0	0	0	1	GREAT CENTRAL VALLEY
283	Pancho Rico Valley	448	134	749	122	615	92	18	71,778	290	1	0	1	99	214	5	0	3	0	0	0	0	0	0	1	CENTRAL COAST
284	Table Mountain/ Chino Canyon	616	182	1,319	205	1,137	93	18	274,428	1,111	14	11	4	86	210	6	18	12	0	0	1	25	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
285	Lone Oak Mountain	231	145	467	72	322	90	16	2,824	11	0	0	0	100	255	2	1	0	0	96	2	96	1	10	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
286		467	167	780	149	613	89	18	9,335	38	13	0	13	87	231	3	3	1	0	0	0	1	1	0	1	CENTRAL COAST
287		411	266	631	57	365	92	17	5,152	21	0	0	0	100	214	3	0	0	0	0	0	0	0	0	1	CENTRAL COAST
288		1,205	1,117	1,439	53	322	73	32	6,520	26	99	89	9	1	242	4	3	8	74	0	0	0	0	6	1	SIERRA NEVADA
289		1,127	1,098	1,172	11	74	79	28	17,865	72	100	100	0	0	231	5	4	8	91	0	0	0	0	10	1	SIERRA NEVADA
290	Stokes Mountain	303	127	653	120	526	84	13	5,683	23	1	0	1	99	248	4	1	0	0	97	1	96	1	1	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
291		346	135	591	98	456	90	20	22,654	92	0	0	0	100	217	4	1	1	0	12	1	12	1	0	1	CENTRAL COAST
292	Tucker Mountain	340	147	778	163	631	90	10	2,019	8	0	0	0	100	248	5	1	1	0	1	1	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
293	Redwood Mountain/ Pine Ridge	1,489	358	2,497	437	2,139	81	30	66,870	271	99	98	1	1	236	22	12	17	0	0	0	0	0	0	1	SIERRA NEVADA
294		85	73	99	6	26	19	35	2,676	11	83	83	0	17	252	5	1	3	0	0	0	0	0	0	1	CENTRAL COAST
295	Death Valley/ Grapevine Mountains	1,060	-2	2,566	579	2,568	95	18	168,809	683	100	100	0	0	163	10	25	4	0	0	0	0	0	0	1	MOJAVE DESERT
296		396	147	759	137	612	90	21	13,860	56	0	0	0	100	224	9	1	3	0	25	1	25	1	0	1	CENTRAL COAST
297		208	112	306	34	194	96	10	2,394	10	0	0	0	100	246	1	0	0	0	0	0	0	0	0	1	CENTRAL COAST
298		402	309	491	28	182	95	11	3,272	13	0	0	0	100	220	2	0	0	0	52	1	52	1	0	1	CENTRAL COAST
299		55	51	57	1	6	1	4	5,540	22	99	99	0	1	197	1	0	2	0	0	0	0	0	1	1	GREAT CENTRAL VALLEY
300	Juniper Ridge	753	239	1,367	224	1,128	94	17	134,156	543	18	0	18	82	217	4	16	12	0	24	2	24	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
301		245	83	398	65	315	94	8	3,012	12	0	0	0	100	240	10	2	1	0	0	0	0	0	0	1	CENTRAL COAST
302		117	3	351	84	348	80	33	2,519	10	86	81	6	14	279	22	5	5	0	0	0	100	1	1	1	CENTRAL COAST
303		281	131	859	150	728	86	18	10,526	43	10	8	2	90	251	8	1	5	0	5	1	0	0	3	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
304		816	267	1,299	207	1,032	93	13	21,292	86	24	13	10	76	257	5	4	7	0	4	1	25	1	0	1	CENTRAL COAST
305		2,551	2,186	2,879	128	693	100	5	10,008	41	100	97	3	0	177	15	1	0	0	0	0	0	0	0	1	SIERRA NEVADA
306	Joaquin Ridge	701	159	1,595	307	1,436	94	16	240,987	975	55	24	31	45	222	6	23	23	0	0	0	44	2	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
307		48	48	49	0	1	75	35	2,330	9	95	21	74	5	208	2	0	4	0	0	0	0	0	77	1	GREAT CENTRAL VALLEY
308	Coyote Ridge	279	129	771	146	642	86	15	23,721	96	0	0	0	100	251	7	1	6	0	1	1	1	1	1	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
309		2,259	1,901	2,487	141	586	64	17	3,163	13	100	96	4	0	200	2	3	0	0	0	0	0	0	1	1	SIERRA NEVADA
310	Inyo Mountains/ Saline Valley/ Death Valley	1,300	-24	3,387	676	3,411	97	15	1,576,727	6,381	100	99	1	0	163	33	77	37	26	0	0	0	1	1	2	MOJAVE DESERT, SIERRA NEVADA
311		305	48	622	130	574	26	21	3,613	15	93	93	0	7	257	2	3	4	45	100	1	100	1	0	1	CENTRAL COAST
312		424	300	594	62	294	95	12	4,231	17	0	0	0	100	242	5	2	5	0	0	0	100	2	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
313	Owens Mountain	185	95	486	62	391	82	16	30,680	124	0	0	0	100	252	6	5	9	0	30	4	51	1	30	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
314	Los Padres National Forest	684	4	1,786	300	1,782	93	18	475,033	1,922	92	77	15	8	263	15	67	27	10	2	4	35	1	0	1	CENTRAL COAST
315		446	161	806	133	645	93	18	63,652	258	65	29	36	35	224	10	6	16	0	0	0	100	2	0	1	GREAT CENTRAL VALLEY
316		762	267	1,422	202	1,155	96	13	194,125	786	12	4	8	88	224	4	16	19	0	16	2	57	3	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
317	James Meadows	210	40	365	58	325	96	14	6,383	26	21	21	0	79	260	10	7	3	100	10	1	80	1	0	1	CENTRAL COAST
318		138	84	285	35	201	65	31	8,235	33	13	9	4	87	249	10	3	8	0	77	5	80	1	20	1	GREAT CENTRAL VALLEY
319		276	21	681	149	660	61	37	6,622	27	72	72	0	28	262	4	4	2	29	0	0	3	1	0	1	CENTRAL COAST
320	Gravelly Ford Canal	58	54	64	2	10	85	18	4,875	20	0	0	0	100	207	1	5	1	0	0	0	0	0	98	1	GREAT CENTRAL VALLEY
321	Pinnacles National Monument	575	147	1,050	159	903	93	19	83,099	336	34	32	2	66	225	5	8	23	0	28	3	48	2	0	1	CENTRAL COAST
322		121	104	135	5	31	75	21	5,586	23	0	0	0	100	225	14	2	5	0	98	4	100	1	97	1	GREAT CENTRAL VALLEY
323		278	96	617	119	521	76	22	19,875	80	61	59	2	39	251	4	6	12	0	32	5	33	1	5	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
324		49	46	52	1	6	77	30	3,135	13	18	18	0	82	210	1	2	1	0	0	0	0	0	89	1	GREAT CENTRAL VALLEY
325	Pilarcitos Canyon	122	12	286	55	274	12	31	10,296	42	95	88	7	5	259	7	16	7	100	23	1	21	2	0	1	CENTRAL COAST

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
281	1	Interior Santa Lucia Range	1	SALINAS	0	1	Monterey	19	70	6	0	0	2	2	0	0
282	4	Westside Alluvial Fans and Terraces, Panoche and Cantua Fans and Basins, Eastern Hills, Kettleman Hills and Valleys	2	COAST RANGE, SOUTH VALLEY FLOOR	47	1	Fresno	0	0	69	2	0	13	7	9	0
283	4	Diablo Range, Interior Santa Lucia Range, Gabilan Range, Paso Robles Hills and Valleys	1	SALINAS	0	1	Monterey	29	38	30	0	0	1	0	0	0
284	5	Diablo Range, Eastern Hills, Gabilan Range, Kettleman Hills and Valleys, Paso Robles Hills and Valleys	5	COAST RANGE, ESTRELLA RIVER, SALINAS, SOUTH VALLEY FLOOR, SUNFLOWER VALLEY	1	5	Fresno, Monterey, Kings, Kern, San Luis Obispo	31	20	47	0	0	1	0	0	0
285	2	Hardpan Terraces, Lower Granitic Foothills	2	KAWEAH RIVER, SOUTH VALLEY FLOOR	0	1	Tulare	2	24	67	2	0	1	1	3	0
286	1	Interior Santa Lucia Range	1	SALINAS	0	1	Monterey	25	62	12	1	0	1	0	0	0
287	1	Gabilan Range	1	SALINAS	0	1	Monterey	7	41	50	0	0	2	0	0	0
288	1	Owens Valley	1	OWENS	0	1	Inyo	0	61	0	11	0	3	0	0	25
289	1	Owens Valley	1	OWENS	0	1	Inyo	0	78	0	17	0	0	0	0	5
290	2	Hardpan Terraces, Lower Granitic Foothills	2	KAWEAH RIVER, SOUTH VALLEY FLOOR	0	1	Tulare	0	43	55	0	1	1	1	0	0
291	2	Interior Santa Lucia Range, Gabilan Range	1	SALINAS	0	1	Monterey	0	51	45	1	0	3	0	1	0
292	2	Hardpan Terraces, Lower Granitic Foothills	2	KAWEAH RIVER, SOUTH VALLEY FLOOR	0	1	Tulare	1	30	52	4	0	0	1	12	0
293	3	Lower Batholith, Upper Batholith, Lower Granitic Foothills	2	KAWEAH RIVER, KINGS RIVER	0	2	Fresno, Tulare	84	10	0	5	0	0	0	0	0
294	1	Watsonville Plain-Salinas Valley	1	SALINAS	0	1	Monterey	0	5	1	25	1	7	61	1	0
295	4	Death Valley, Amargosa Desert-Pahrump Valley, Funeral Mountains-Greenwater Valley, Grapevine Mountains	1	AMARGOSA	0	1	Inyo	5	43	0	5	0	0	0	0	47
296	1	Gabilan Range	1	SALINAS	0	2	San Benito, Monterey	10	48	35	1	0	2	1	3	0
297	2	Watsonville Plain-Salinas Valley, Gabilan Range	1	SALINAS	0	1	Monterey	0	52	45	3	0	1	0	0	0
298	1	Gabilan Range	1	SALINAS	0	2	San Benito, Monterey	1	17	81	0	0	1	0	0	0
299	2	Granitic Alluvial Fans and Terraces, Panoche and Cantua Fans and Basins	1	SOUTH VALLEY FLOOR	0	1	Fresno	0	1	1	1	0	5	87	5	0
300	4	Diablo Range, Eastern Hills, Gabilan Range, Kettleman Hills and Valleys	4	COAST RANGE, PAJARO RIVER, SALINAS, SOUTH VALLEY FLOOR	0	3	Fresno, San Benito, Monterey	51	23	23	0	0	1	0	1	1
301	1	Gabilan Range	1	SALINAS	0	1	Monterey	1	82	13	3	0	1	0	0	0
302	1	North Costal Santa Lucia Range	1	SANTA LUCIA	0	1	Monterey	32	58	1	1	0	3	3	1	1
303	4	Hardpan Terraces, Hardpan Terraces, Granitic Alluvial Fans and Terraces, Lower Granitic Foothills	2	KINGS RIVER, SOUTH VALLEY FLOOR	0	1	Fresno	1	30	56	9	1	1	2	0	0
304	3	Watsonville Plain-Salinas Valley, North Costal Santa Lucia Range, Interior Santa Lucia Range	2	CARMEL RIVER, SALINAS	0	1	Monterey	2	83	12	1	0	1	0	0	2
305	1	Inyo Mountains	2	EUREKA, OWENS	0	1	Inyo	40	54	2	0	0	0	0	0	4
306	5	Westside Alluvial Fans and Terraces, Panoche and Cantua Fans and Basins, Diablo Range, Eastern Hills, Kettleman Hills and Valleys	3	COAST RANGE, PAJARO RIVER, SOUTH VALLEY FLOOR	17	2	Fresno, San Benito	26	21	50	0	0	1	0	0	2
307	1	Granitic Alluvial Fans and Terraces	1	SOUTH VALLEY FLOOR	0	1	Fresno	0	2	4	57	11	3	22	0	0
308	3	Hardpan Terraces, Granitic Alluvial Fans and Terraces, Lower Granitic Foothills	2	KINGS RIVER, SOUTH VALLEY FLOOR	0	1	Fresno	0	20	76	2	0	0	2	0	0
309	1	Upper Batholith	1	KINGS RIVER	0	1	Fresno	93	2	0	5	0	0	0	0	1
310	7	Owens Valley, Death Valley, Panamint Valley, Benton-Upper Owens Valleys, Inyo Mountains, Saline Valley-Cottonwood Mountains, Cosa-Argus Ranges	6	AMARGOSA, BALLARAT, EUREKA, OWENS, RACE TRACK, SALINE	1	1	Inyo	11	36	0	2	0	0	0	0	51
311	1	North Costal Santa Lucia Range	1	CARMEL RIVER	0	1	Monterey	19	78	1	0	0	2	0	0	0
312	2	Westside Alluvial Fans and Terraces, Eastern Hills	3	COAST RANGE, DELTA-MENDOTA CANAL, MIDDLE WEST SIDE	0	2	Fresno, San Benito	0	5	94	0	0	1	0	0	0
313	3	Hardpan Terraces, Hardpan Terraces, Lower Granitic Foothills	4	KINGS RIVER, SAN JOAQUIN RIVER, SAN JOAQUIN VALLEY FLOOR, SOUTH VALLEY FLOOR	0	1	Fresno	0	12	84	1	1	1	1	0	0
314	3	North Costal Santa Lucia Range, South Costal Santa Lucia Range, Interior Santa Lucia Range	4	CARMEL RIVER, ESTERO BAY, SALINAS, SANTA LUCIA	1	2	Monterey, San Luis Obispo	27	61	4	1	0	1	0	0	6
315	2	Westside Alluvial Fans and Terraces, Eastern Hills	4	COAST RANGE, DELTA-MENDOTA CANAL, MIDDLE WEST SIDE, SOUTH VALLEY FLOOR	7	2	Fresno, San Benito	1	23	72	1	0	2	0	0	2
316	2	Diablo Range, Eastern Hills	3	COAST RANGE, PAJARO RIVER, SALINAS	3	1	San Benito	44	24	30	1	0	1	0	0	0
317	1	North Costal Santa Lucia Range	2	CARMEL RIVER, SALINAS	0	1	Monterey	19	75	3	0	0	2	0	0	0
318	2	Hardpan Terraces, Lower Granitic Foothills	3	AHWAHNEE, SAN JOAQUIN VALLEY FLOOR, SOUTH VALLEY FLOOR	0	2	Madera, Fresno	0	8	76	4	1	3	6	2	0
319	2	Watsonville Plain-Salinas Valley, North Costal Santa Lucia Range	1	SALINAS	0	1	Monterey	1	85	8	2	0	4	0	0	0
320	1	Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	95	0	0	3	1	2	0
321	2	Diablo Range, Gabilan Range	2	PAJARO RIVER, SALINAS	0	2	San Benito, Monterey	36	43	19	1	0	1	0	0	0
322	2	Hardpan Terraces, Lower Granitic Foothills	2	AHWAHNEE, SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	1	97	0	0	2	0	0	0
323	1	Lower Granitic Foothills	3	AHWAHNEE, SAN JOAQUIN RIVER, SAN JOAQUIN VALLEY FLOOR	0	2	Madera, Fresno	0	56	36	4	2	0	0	0	1
324	1	Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	67	7	0	5	8	12	0
325	2	Watsonville Plain-Salinas Valley, North Costal Santa Lucia Range	1	SALINAS	69	1	Monterey	3	67	15	1	0	14	0	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
326		1,580	619	2,719	444	2,100	95	17	256,249	1,037	100	99	1	0	163	29	28	18	0	0	0	0	0	0	2	MOJAVE DESERT, SIERRA NEVADA
327	Fresno River	53	50	57	2	7	86	20	3,128	13	0	0	0	100	212	1	0	2	0	0	0	0	0	94	1	GREAT CENTRAL VALLEY
328		353	206	493	44	287	72	33	3,049	12	98	97	2	2	248	0	1	5	0	0	0	0	0	0	1	SIERRA NEVADA
329	Lone Willow	43	41	46	1	5	90	14	7,312	30	0	0	0	100	215	5	1	2	0	0	0	0	0	96	1	GREAT CENTRAL VALLEY
330		125	100	189	19	89	79	29	4,600	19	0	0	0	100	231	15	1	4	0	0	4	71	1	58	1	GREAT CENTRAL VALLEY
331		144	98	308	28	210	81	23	27,170	110	11	11	0	89	240	8	3	8	0	24	5	81	1	39	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
332	Ash Slough	39	37	40	1	3	87	18	2,899	12	0	0	0	100	217	4	1	0	0	0	0	0	0	88	1	GREAT CENTRAL VALLEY
333	San Luis Canal	34	30	46	3	16	91	14	17,344	70	91	78	13	9	211	3	1	3	0	0	0	0	0	94	1	GREAT CENTRAL VALLEY
334		5	0	59	7	59	13	10	2,855	12	91	89	2	9	265	17	1	11	0	26	3	100	1	41	1	CENTRAL COAST
335		80	74	87	2	13	85	21	2,588	10	0	0	0	100	207	1	0	2	0	97	2	98	1	89	1	GREAT CENTRAL VALLEY
336	Eastman Lake NRA	151	82	309	45	227	89	18	42,805	173	7	7	0	93	232	13	6	11	0	30	6	43	1	34	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
337	Santa Cruz Mountains/ Pescadero Creek	225	34	552	104	518	84	10	14,419	58	0	0	0	100	265	9	3	5	0	0	0	15	1	0	1	CENTRAL COAST
338	Merced National Wildlife Refuge	32	29	34	1	5	44	40	5,158	21	91	78	12	9	222	2	2	5	0	5	5	5	1	62	1	GREAT CENTRAL VALLEY
339		2,228	1,812	2,539	143	727	73	18	7,386	30	100	97	3	0	211	7	1	2	0	0	0	0	0	2	1	SIERRA NEVADA
340	Ortigalita Ridge/ San Luis Reservoir	491	66	1,133	229	1,067	93	16	313,336	1,268	7	5	2	93	225	8	14	25	0	4	2	89	2	1	2	CENTRAL COAST, GREAT CENTRAL VALLEY
341	Flat Top Mountain	259	85	629	107	544	84	26	30,628	124	0	0	0	100	238	8	2	1	0	19	4	19	1	12	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
342	Pigeon Point	338	86	541	100	455	81	11	6,020	24	17	17	0	83	246	10	0	2	0	1	1	44	1	0	1	CENTRAL COAST
343		138	72	377	59	305	87	26	28,827	117	23	23	0	77	227	11	10	11	0	55	7	56	1	44	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
344	San Luis Island	25	20	28	1	8	78	26	11,273	46	99	73	26	1	224	1	4	14	0	14	5	15	1	91	1	GREAT CENTRAL VALLEY
345	San Andreas Rift	484	174	808	130	634	75	13	2,970	12	9	9	0	91	274	1	1	2	0	0	0	0	0	0	1	CENTRAL COAST
346	Bear Creek	29	24	35	2	11	89	18	12,057	49	100	57	43	0	221	1	10	12	0	61	5	61	1	82	1	GREAT CENTRAL VALLEY
347	Sugarloaf Mountain	376	10	795	180	785	55	38	13,560	55	80	73	7	20	276	4	6	6	0	0	0	98	1	0	1	CENTRAL COAST
348	Kesterson National Wildlife Refuge	24	17	30	2	13	80	26	35,823	145	99	81	19	1	219	4	9	15	0	3	4	16	1	93	1	GREAT CENTRAL VALLEY
349	San Andreas Rift	724	499	959	91	460	59	11	2,289	9	27	0	27	73	271	1	5	0	0	0	0	99	1	0	1	CENTRAL COAST
350	Bonny Doon	409	190	587	80	397	23	24	2,288	9	61	61	0	39	274	13	9	2	0	0	0	100	1	0	1	CENTRAL COAST
351		347	268	443	30	175	94	13	2,191	9	0	0	0	100	249	1	0	0	95	0	0	0	0	0	1	SIERRA NEVADA
352		123	62	367	50	305	83	25	51,679	209	39	39	0	61	225	12	15	14	0	36	8	83	1	74	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
353		68	54	90	8	36	69	16	3,362	14	0	0	0	100	214	1	0	0	0	99	6	99	1	98	1	GREAT CENTRAL VALLEY
354		19	16	22	1	6	72	20	3,489	14	91	30	61	9	224	1	3	3	0	0	0	0	0	60	1	GREAT CENTRAL VALLEY
355		432	102	793	158	691	4	12	2,273	9	96	96	0	4	270	0	6	4	0	85	1	1	1	0	1	CENTRAL COAST
356		2,453	1,192	4,331	737	3,139	94	19	379,769	1,537	100	88	12	0	222	24	67	38	67	0	0	2	1	1	1	SIERRA NEVADA
357		281	117	454	69	337	9	8	2,997	12	94	94	0	6	269	1	3	3	0	6	1	0	0	0	1	CENTRAL COAST
358		95	57	153	19	96	85	22	7,923	32	50	50	0	50	216	1	2	11	0	69	6	69	1	76	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
359		593	348	947	143	599	94	9	11,005	45	2	0	2	98	252	5	0	2	100	0	0	0	0	0	1	SIERRA NEVADA
360	Table Top Mountain	143	73	237	32	164	90	21	25,962	105	30	30	0	70	218	8	6	14	0	98	7	98	1	77	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
361	Santa Cruz Mountains	438	94	1,154	210	1,060	71	23	54,622	221	44	27	17	56	262	9	15	7	0	3	2	1	1	0	1	CENTRAL COAST
362		1,162	358	2,108	329	1,750	82	28	55,048	223	90	80	10	10	233	8	19	26	17	0	0	0	0	0	1	SIERRA NEVADA
363		2,052	1,249	3,397	524	2,148	80	29	194,401	787	98	86	13	2	230	8	28	24	11	4	2	28	2	5	1	SIERRA NEVADA
364		881	358	1,521	239	1,163	85	29	10,650	43	81	52	29	19	237	5	6	4	73	0	0	0	0	0	1	SIERRA NEVADA
365		547	220	973	168	753	62	19	7,110	29	68	68	0	32	266	1	6	2	0	28	1	0	1	0	1	CENTRAL COAST
366	Castle Rock	635	268	949	154	681	52	25	3,804	15	88	85	3	12	267	2	3	2	0	1	1	0	0	0	1	CENTRAL COAST
367	Hunter Valley Mountain	552	255	970	139	715	86	25	13,195	53	60	20	40	40	256	7	5	1	98	0	0	0	0	0	1	SIERRA NEVADA
368		1,507	689	1,955	249	1,266	56	36	8,302	34	100	96	3	0	226	4	8	17	0	0	0	0	0	1	1	SIERRA NEVADA
369		2,275	2,010	2,775	168	765	80	30	17,807	72	100	99	1	0	253	6	3	2	0	0	0	47	1	0	1	SIERRA NEVADA
370		670	251	1,075	175	824	93	19	38,861	157	79	11	68	21	270	17	8	10	100	0	0	0	0	0	1	SIERRA NEVADA
371	Cardoza Ridge	125	79	263	33	184	93	10	21,371	86	0	0	0	100	237	14	6	17	0	78	6	73	1	32	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
372		84	39	131	14	92	88	21	29,387	119	7	7	0	93	220	8	9	10	0	86	6	87	1	68	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
373		83	6	189	41	183	74	26	7,184	29	85	81	4	15	305	18	3	5	0	0	1	100	1	3	1	CENTRAL COAST

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
326	7	Death Valley, Benton-Upper Owens Valleys, White Mountains, Silver Peak Mountains-Fish Lake Valley, Inyo Mountains, Saline Valley-Cottonwood Mountains, Grapevine Mountains	5	AMARGOSA, DEEP SPRINGS, EUREKA, FISH LAKE, OWENS	0	1	Inyo	19	69	0	1	0	0	0	0	11
327	2	Hardpan Terraces, Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	35	4	0	2	40	19	0
328	1	Lower Granitic Foothills	2	AHWAHNEE, SAN JOAQUIN RIVER	0	1	Madera	0	52	39	8	0	0	0	0	0
329	1	Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	83	4	0	1	6	7	0
330	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	2	AHWAHNEE, SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	1	97	0	0	2	0	0	0
331	3	Hardpan Terraces, Lower Foothills Metamorphic Belt, Lower Granitic Foothills	2	AHWAHNEE, SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	8	86	2	2	2	0	0	1
332	2	San Joaquin Basin, Granitic Alluvial Fans and Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Madera	0	0	80	2	0	1	7	11	0
333	2	Westside Alluvial Fans and Terraces, San Joaquin Basin	1	DELTA-MENDOTA CANAL	0	1	Merced	0	1	3	69	1	3	18	5	0
334	1	Watsonville Plain-Salinas Valley	2	BOLSA NUEVA, SALINAS	0	1	Monterey	4	13	2	42	25	9	1	1	1
335	1	Hardpan Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	2	Madera, Merced	0	0	79	0	0	0	11	9	0
336	3	Hardpan Terraces, Lower Foothills Metamorphic Belt, Lower Granitic Foothills	3	AHWAHNEE, MARIPOSA, SAN JOAQUIN VALLEY FLOOR	0	3	Mariposa, Madera, Merced	0	8	86	1	2	1	1	0	0
337	3	Santa Clara Valley, Santa Cruz Mountains, Leeward Hills	1	PAJARO RIVER	0	3	Santa Clara, Santa Cruz, San Benito	8	69	19	1	0	2	0	0	0
338	2	Manteca-Merced Alluvium, San Joaquin Basin	1	SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	2	5	47	1	6	32	7	0
339	2	Lower Batholith, Upper Batholith	1	SAN JOAQUIN RIVER	0	1	Madera	73	4	0	3	0	0	0	0	19
340	4	Westside Alluvial Fans and Terraces, Western Diablo Range, Diablo Range, Eastern Hills	4	COAST RANGE, DELTA-MENDOTA CANAL, MIDDLE WEST SIDE, PAJARO RIVER	0	4	Merced, Fresno, Santa Clara, San Benito	11	19	67	1	0	2	0	0	0
341	4	Hardpan Terraces, Manteca-Merced Alluvium, Lower Foothills Metamorphic Belt, Lower Granitic Foothills	3	AHWAHNEE, MARIPOSA, SAN JOAQUIN VALLEY FLOOR	0	2	Mariposa, Merced	0	34	62	3	0	0	1	0	0
342	2	Santa Clara Valley, Western Diablo Range	2	PAJARO RIVER, SANTA CLARA	0	1	Santa Clara	6	61	29	1	0	2	0	0	0
343	3	Hardpan Terraces, Manteca-Merced Alluvium, Lower Foothills Metamorphic Belt	2	MARIPOSA, SAN JOAQUIN VALLEY FLOOR	0	2	Mariposa, Merced	0	10	85	1	0	1	2	1	0
344	1	San Joaquin Basin	2	DELTA-MENDOTA CANAL, SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	5	13	74	0	3	1	3	0
345	2	Santa Cruz Mountains, Watsonville Plain-Salinas Valley	1	PAJARO RIVER	0	1	Santa Cruz	56	41	1	0	0	1	0	0	0
346	2	Manteca-Merced Alluvium, San Joaquin Basin	1	SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	0	31	47	0	2	6	14	0
347	2	Santa Cruz Mountains, Watsonville Plain-Salinas Valley	2	BIG BASIN, PAJARO RIVER	0	1	Santa Cruz	90	7	0	0	0	3	0	0	0
348	2	Manteca-Merced Alluvium, San Joaquin Basin	2	DELTA-MENDOTA CANAL, SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	1	5	82	2	3	6	1	0
349	1	Santa Cruz Mountains	3	BIG BASIN, PAJARO RIVER, SANTA CLARA	0	1	Santa Cruz	70	25	3	1	0	1	0	0	0
350	1	Santa Cruz Mountains	1	BIG BASIN	0	1	Santa Cruz	69	23	2	1	0	4	1	0	0
351	2	Lower Foothills Metamorphic Belt, Lower Granitic Foothills	1	MARIPOSA	0	1	Mariposa	0	57	33	10	0	0	0	0	0
352	4	Hardpan Terraces, Camanche Terraces, Manteca-Merced Alluvium, Lower Foothills Metamorphic Belt	2	MARIPOSA, SAN JOAQUIN VALLEY FLOOR	0	2	Mariposa, Merced	0	3	93	1	0	1	0	0	0
353	2	Hardpan Terraces, Manteca-Merced Alluvium	1	SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	1	90	2	1	1	6	0	0
354	2	Manteca-Merced Alluvium, San Joaquin Basin	2	DELTA-MENDOTA CANAL, SAN JOAQUIN VALLEY FLOOR	0	2	Stanislaus, Merced	0	1	22	67	4	1	1	4	0
355	1	Santa Cruz Mountains	1	BIG BASIN	0	1	Santa Cruz	92	5	0	0	0	2	0	0	0
356	4	Benton-Upper Owens Valleys, White Mountains, Silver Peak Mountains-Fish Lake Valley, Inyo Mountains	3	DEEP SPRINGS, FISH LAKE, OWENS	0	2	Mono, Inyo	40	39	0	2	0	1	0	1	17
357	1	Santa Cruz Mountains	1	BIG BASIN	0	1	Santa Cruz	82	11	0	1	5	1	0	0	0
358	2	Hardpan Terraces, Manteca-Merced Alluvium	1	SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	1	80	2	0	3	5	8	0
359	2	Lower Foothills Metamorphic Belt, Lower Granitic Foothills	2	MARIPOSA, MERCED RIVER	0	1	Mariposa	2	85	9	4	0	0	0	0	0
360	3	Hardpan Terraces, Camanche Terraces, Lower Foothills Metamorphic Belt	2	MERCED RIVER, SAN JOAQUIN VALLEY FLOOR	0	1	Merced	0	1	96	1	0	0	0	0	0
361	3	Santa Cruz Mountains, Leeward Hills, Watsonville Plain-Salinas Valley	3	BIG BASIN, PAJARO RIVER, SANTA CLARA	0	2	Santa Clara, Santa Cruz	29	63	4	1	0	2	0	0	0
362	2	Upper Foothills Metamorphic Belt, Lower Batholith	1	MERCED RIVER	1	1	Mariposa	81	14	0	4	0	0	0	0	1
363	4	Eastern Slopes, Crowley Flowlands, Benton-Upper Owens Valleys, Glass Mountain	3	ADOBE, MONO, OWENS	20	2	Mono, Inyo	30	58	0	6	0	0	0	1	4
364	1	Upper Foothills Metamorphic Belt	1	MERCED RIVER	0	1	Mariposa	56	40	0	3	0	0	0	0	0
365	1	Santa Cruz Mountains	3	BIG BASIN, SAN MATEO, SANTA CLARA	0	2	San Mateo, Santa Cruz	77	20	1	0	0	1	0	0	0
366	1	Santa Cruz Mountains	2	BIG BASIN, SANTA CLARA	0	1	Santa Clara	57	40	0	0	0	2	0	0	0
367	1	Lower Foothills Metamorphic Belt	2	MARIPOSA, MERCED RIVER	19	1	Mariposa	1	75	0	3	1	0	0	0	21
368	2	Upper Foothills Metamorphic Belt, Lower Batholith	1	MERCED RIVER	0	1	Mariposa	81	12	0	6	0	1	0	0	0
369	4	Eastern Slopes, Mono Valley, Crowley Flowlands, Glass Mountain	1	MONO	0	1	Mono	13	72	0	0	0	0	0	0	15
370	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	2	MARIPOSA, MERCED RIVER	11	1	Mariposa	31	65	0	4	0	0	0	0	0
371	3	Hardpan Terraces, Camanche Terraces, Lower Foothills Metamorphic Belt	3	MERCED RIVER, SAN JOAQUIN VALLEY FLOOR, TUOLUMNE RIVER	0	3	Stanislaus, Mariposa, Merced	0	13	72	12	1	0	1	1	0
372	2	Hardpan Terraces, Camanche Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	2	Stanislaus, Merced	0	3	82	3	1	3	7	1	0
373	1	Santa Cruz Mountains	2	BIG BASIN, SAN MATEO	0	1	San Mateo	8	69	7	6	1	2	7	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
374		282	2	839	156	837	77	26	86,524	350	55	54	1	45	283	23	38	26	6	53	3	100	1	0	1	CENTRAL COAST
375	Sierra Nevada	2,503	268	4,409	722	4,141	86	22	3,676,447	14,878	99	97	2	1	180	45	162	85	12	13	4	0	2	2	2	MOJAVE DESERT, SIERRA NEVADA
376		403	135	783	123	648	70	23	4,002	16	68	43	25	32	270	1	2	4	100	0	1	100	1	0	1	CENTRAL COAST
377		540	140	856	158	716	54	37	5,435	22	89	49	40	11	273	3	6	1	91	0	0	32	2	0	1	CENTRAL COAST
378		150	0	379	81	379	68	26	12,765	52	24	24	0	76	276	19	6	9	5	3	2	100	1	2	1	CENTRAL COAST
379		60	34	82	8	48	78	19	5,706	23	0	0	0	100	218	4	3	0	0	57	3	57	1	81	1	GREAT CENTRAL VALLEY
380		83	46	134	14	88	91	19	32,812	133	6	6	0	94	230	12	14	5	0	96	4	91	1	71	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
381		96	67	181	20	114	91	16	3,074	12	0	0	0	100	250	4	4	3	0	91	4	91	1	41	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
382		67	46	114	9	68	66	30	4,404	18	0	0	0	100	218	3	1	1	0	15	3	75	1	64	1	GREAT CENTRAL VALLEY
383		10	6	17	2	11	22	32	7,605	31	91	91	0	9	225	1	3	5	86	0	0	0	0	18	1	GREAT CENTRAL VALLEY
384		2,132	1,704	2,696	164	992	94	18	165,033	668	97	56	41	3	227	16	24	21	0	0	0	58	1	1	1	SIERRA NEVADA
385		268	11	721	139	710	77	20	15,808	64	44	16	29	56	269	5	4	3	65	0	0	100	1	0	1	CENTRAL COAST
386		642	333	941	147	608	85	21	2,429	10	96	92	3	4	269	11	0	0	0	0	0	0	0	0	1	SIERRA NEVADA
387		365	244	509	42	265	93	18	4,132	17	94	94	0	6	253	3	7	1	0	0	0	0	0	0	1	SIERRA NEVADA
388		10	5	14	2	9	26	33	8,513	34	90	90	0	10	226	1	2	12	100	11	3	8	1	28	1	GREAT CENTRAL VALLEY
389		119	70	217	30	147	92	14	4,211	17	0	0	0	100	247	3	2	3	0	17	4	67	1	21	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
390		99	49	182	23	133	90	15	20,554	83	0	0	0	100	227	10	5	7	0	6	4	93	1	35	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
391		1	0	42	2	42	8	24	21,485	87	95	95	0	5	285	9	9	14	100	0	2	3	1	28	1	CENTRAL COAST
392	Mt Allison	390	74	805	191	731	31	41	12,918	52	85	85	0	15	262	13	2	8	6	18	1	55	1	0	1	CENTRAL COAST
393		2,095	1,967	2,569	124	602	91	23	13,625	55	93	23	70	7	227	6	8	0	0	0	0	71	1	1	1	SIERRA NEVADA
394		382	315	528	39	213	74	30	3,346	14	96	96	1	4	249	0	8	6	0	0	0	0	0	0	1	SIERRA NEVADA
395		221	25	636	122	611	74	19	15,187	61	54	36	18	46	287	21	0	2	7	0	0	100	1	1	1	CENTRAL COAST
396		167	52	389	81	337	47	40	2,557	10	69	69	0	31	264	1	2	9	0	0	0	98	1	2	1	CENTRAL COAST
397		280	86	638	151	552	40	34	6,993	28	100	100	0	0	281	5	14	7	67	10	3	100	1	2	1	CENTRAL COAST
398		2,423	2,044	2,742	121	698	96	15	16,875	68	92	0	92	8	231	10	4	3	0	0	0	96	1	1	1	SIERRA NEVADA
399		1	0	3	1	3	7	23	5,855	24	93	93	0	7	292	1	1	13	100	0	0	0	0	55	1	CENTRAL COAST
400		388	226	607	100	381	83	22	2,350	10	13	9	4	87	236	6	1	1	0	0	0	100	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
401	Diablo Range	516	50	1,316	244	1,266	91	19	762,975	3,088	36	35	2	64	232	8	44	40	1	13	4	54	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
402		299	85	652	127	567	89	16	17,730	72	2	1	1	98	245	7	7	17	0	25	2	93	1	0	1	GREAT CENTRAL VALLEY
403	Mountain House	240	92	524	100	432	86	21	6,216	25	0	0	0	100	229	10	1	6	0	0	0	98	1	1	1	GREAT CENTRAL VALLEY
404		80	44	126	12	82	75	21	17,613	71	3	3	0	97	221	6	1	4	0	2	1	75	1	63	1	GREAT CENTRAL VALLEY
405		3	0	83	6	83	5	17	10,551	43	95	95	0	5	279	6	1	15	44	0	0	0	0	24	1	CENTRAL COAST
406		1,051	704	1,550	157	846	96	13	3,702	15	95	1	94	5	234	3	3	0	0	0	0	100	1	0	1	SIERRA NEVADA
407	Garin Regional Park	199	18	397	81	379	0	0	3,237	13	93	93	0	7	268	3	1	4	0	75	1	100	1	1	1	CENTRAL COAST
408	Sunol Ridge	349	70	651	117	581	7	14	6,814	28	91	91	0	9	259	2	2	3	0	91	1	100	1	1	1	CENTRAL COAST
409	Gopher Ridge	187	46	476	102	430	87	17	43,036	174	0	0	0	100	240	10	2	9	0	0	0	35	1	24	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
410		55	37	82	8	45	89	20	7,332	30	0	0	0	100	219	1	0	0	0	26	1	13	1	24	1	GREAT CENTRAL VALLEY
411	Montara Mountain	242	14	586	110	572	24	41	24,112	98	86	86	0	14	279	17	28	15	4	39	2	99	1	1	1	CENTRAL COAST
412		245	146	362	43	216	84	16	3,637	15	0	0	0	100	236	9	1	9	0	0	0	100	1	0	1	GREAT CENTRAL VALLEY
413		49	34	70	7	36	88	17	3,326	13	0	0	0	100	218	0	1	3	0	86	2	70	1	55	1	GREAT CENTRAL VALLEY
414		203	127	332	37	205	82	19	4,626	19	19	1	18	81	235	3	3	11	0	0	0	100	1	0	1	GREAT CENTRAL VALLEY
415		495	319	668	66	349	71	6	3,717	15	20	0	20	80	255	8	0	3	0	0	0	0	0	0	1	SIERRA NEVADA
416		410	155	864	115	709	83	14	25,548	103	17	0	17	83	245	3	4	3	0	0	0	26	2	0	1	SIERRA NEVADA
417		429	329	616	76	287	74	23	4,514	18	0	0	0	100	244	0	3	0	0	0	0	0	0	10	1	SIERRA NEVADA
418		243	62	470	121	408	80	22	25,773	104	10	10	0	90	243	7	3	2	0	0	0	6	1	9	2	SIERRA NEVADA, GREAT CENTRAL VALLEY

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
374	2	Santa Cruz Mountains, Watsonville Plain-Salinas Valley	3	BIG BASIN, SAN MATEO, SANTA CLARA	0	2	San Mateo, Santa Cruz	70	23	3	1	0	2	1	0	0
375	14	Glaciated Batholith, Upper Batholith, Eastern Slopes, Kern Plateau, Lower Batholith, Owens Valley, Lower Granitic Foothills, Benton-Upper Owens Valleys, and 6 others	10	INDIAN WELLS, KAWEAH RIVER, KERN RIVER, KINGS RIVER, MERCED RIVER, MONO, OWENS, SAN JOAQUIN RIVER, SOUTHERN SIERRA, TUOLUMNE RIVER	1	8	Mono, Tuolumne, Mariposa, Madera, Fresno, Inyo, Tulare, Kern	53	15	0	3	1	0	0	0	28
376	1	Santa Cruz Mountains	1	SAN MATEO	0	1	San Mateo	49	39	8	1	0	3	0	0	0
377	1	Santa Cruz Mountains	2	SAN MATEO, SANTA CLARA	0	1	Santa Clara	53	40	4	0	0	2	0	0	0
378	1	Santa Cruz Mountains	1	SAN MATEO	0	1	San Mateo	16	69	9	3	0	2	1	0	0
379	2	Camanche Terraces, Manteca-Merced Alluvium	1	SAN JOAQUIN VALLEY FLOOR	0	1	Stanislaus	0	2	60	5	0	3	24	6	0
380	2	Camanche Terraces, Lower Foothills Metamorphic Belt	1	SAN JOAQUIN VALLEY FLOOR	0	1	Stanislaus	0	1	83	5	1	2	5	2	0
381	2	Camanche Terraces, Lower Foothills Metamorphic Belt	2	SAN JOAQUIN VALLEY FLOOR, TUOLUMNE RIVER	0	2	Tuolumne, Stanislaus	0	4	78	15	0	3	0	0	0
382	1	Camanche Terraces	1	SAN JOAQUIN VALLEY FLOOR	0	1	Stanislaus	0	1	70	1	0	1	21	6	0
383	3	Sodic Claypan Terraces, Westside Alluvial Fans and Terraces, Manteca-Merced Alluvium	2	DELTA-MENDOTA CANAL, SAN JOAQUIN VALLEY FLOOR	0	1	Stanislaus	0	1	4	22	3	4	39	26	0
384	5	Eastern Slopes, Bodie Hills-Excelsior Mountains, Mono Valley, Crowley Flowlands, Glass Mountain	3	ADOBE, MONO, OWENS	0	1	Mono	27	68	0	0	0	0	0	0	5
385	1	Santa Cruz Mountains	1	SAN MATEO	0	1	San Mateo	27	56	13	2	0	1	0	0	0
386	1	Lower Foothills Metamorphic Belt	1	TUOLUMNE RIVER	0	1	Tuolumne	17	79	0	4	0	0	0	0	0
387	1	Lower Foothills Metamorphic Belt	2	STANISLAUS RIVER, TUOLUMNE RIVER	94	1	Tuolumne	0	96	0	3	1	0	0	0	0
388	3	Sodic Claypan Terraces, Westside Alluvial Fans and Terraces, Manteca-Merced Alluvium	3	DELTA-MENDOTA CANAL, SAN JOAQUIN DELTA, SAN JOAQUIN VALLEY FLOOR	0	2	San Joaquin, Stanislaus	0	1	7	18	3	3	14	55	0
389	2	Camanche Terraces, Lower Foothills Metamorphic Belt	3	SAN JOAQUIN VALLEY FLOOR, STANISLAUS RIVER, TUOLUMNE RIVER	0	2	Tuolumne, Stanislaus	0	1	93	4	0	2	0	0	0
390	2	Camanche Terraces, Lower Foothills Metamorphic Belt	2	SAN JOAQUIN VALLEY FLOOR, TUOLUMNE RIVER	0	1	Stanislaus	0	4	88	3	0	2	2	2	0
391	1	Bay Flats	2	SANTA CLARA, SOUTH BAY	0	3	Alameda, San Mateo, Santa Clara	0	5	0	29	58	8	0	0	0
392	2	Bay Flats, Fremont-Livermore Hills and Valleys	2	SANTA CLARA, SOUTH BAY	0	2	Alameda, Santa Clara	5	39	43	1	0	11	0	0	0
393	2	Bodie Hills-Excelsior Mountains, Mono Valley	1	MONO	0	1	Mono	19	80	0	0	0	0	0	0	0
394	1	Lower Foothills Metamorphic Belt	2	STANISLAUS RIVER, TUOLUMNE RIVER	86	1	Tuolumne	0	97	0	3	0	0	0	0	0
395	1	Santa Cruz Mountains	2	SAN MATEO, SOUTH BAY	0	1	San Mateo	17	71	5	2	0	2	2	0	0
396	2	East Bay Hills-Mt. Diablo, Fremont-Livermore Hills and Valleys	2	SANTA CLARA, SOUTH BAY	0	1	Alameda	1	34	47	1	0	17	0	0	0
397	1	Santa Cruz Mountains	3	SAN MATEO, SANTA CLARA, SOUTH BAY	0	1	San Mateo	56	30	1	3	2	6	2	0	0
398	3	Sweetwater Mountains-Pine Grove Hills, Bodie Hills-Excelsior Mountains, Mono Valley	2	EAST WALKER RIVER, MONO	0	1	Mono	20	78	0	0	0	0	0	0	2
399	2	Bay Flats, Santa Clara Valley	1	SOUTH BAY	0	1	San Mateo	0	2	1	71	24	3	0	0	0
400	2	Fremont-Livermore Hills and Valleys, Eastern Hills	1	SOUTH BAY	0	1	Alameda	0	6	88	0	0	2	4	0	0
401	6	Santa Clara Valley, Westside Alluvial Fans and Terraces, Fremont-Livermore Hills and Valleys, Western Diablo Range, Diablo Range, Eastern Hills	7	CARBONA, DELTA-MENDOTA CANAL, MIDDLE WEST SIDE, NORTH DIABLO RANGE, PAJARO RIVER, SANTA CLARA, SOUTH BAY	0	5	San Joaquin, Stanislaus, Alameda, Merced, Santa Clara	35	30	33	1	0	1	0	0	0
402	2	Westside Alluvial Fans and Terraces, Eastern Hills	3	CARBONA, NORTH DIABLO RANGE, SOUTH BAY	0	2	San Joaquin, Alameda	0	4	90	0	0	1	0	0	5
403	2	Westside Alluvial Fans and Terraces, Eastern Hills	3	CARBONA, NORTH DIABLO RANGE, SOUTH BAY	0	1	Alameda	0	1	99	0	0	0	0	0	1
404	2	Hardpan Terraces, Camanche Terraces	2	NORTH VALLEY FLOOR, SAN JOAQUIN VALLEY FLOOR	0	1	Stanislaus	0	2	86	3	1	3	2	3	0
405	1	Bay Flats	2	SANTA CLARA, SOUTH BAY	0	1	Alameda	0	8	1	19	65	7	0	0	0
406	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	1	TUOLUMNE RIVER	0	1	Tuolumne	83	13	0	5	0	0	0	0	0
407	2	Bay Flats, East Bay Hills-Mt. Diablo	1	SOUTH BAY	0	1	Alameda	2	44	46	0	0	8	0	0	0
408	2	East Bay Hills-Mt. Diablo, Fremont-Livermore Hills and Valleys	1	SOUTH BAY	0	1	Alameda	4	59	30	2	0	5	0	0	0
409	2	Camanche Terraces, Lower Foothills Metamorphic Belt	4	GOPHER RIDGE, NORTH VALLEY FLOOR, SAN JOAQUIN VALLEY FLOOR, STANISLAUS RIVER	0	3	Calaveras, Tuolumne, Stanislaus	0	25	69	3	0	1	1	1	0
410	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	2	San Joaquin, Stanislaus	0	2	89	3	0	2	1	2	0
411	2	Santa Cruz Mountains, Leeward Hills	2	SAN MATEO, SOUTH BAY	0	1	San Mateo	24	66	1	1	3	4	1	0	0
412	1	Fremont-Livermore Hills and Valleys	1	SOUTH BAY	0	2	Contra Costa, Alameda	0	3	94	1	0	3	0	0	0
413	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	1	San Joaquin	0	0	95	0	0	0	4	0	0
414	1	Fremont-Livermore Hills and Valleys	1	SOUTH BAY	0	2	Contra Costa, Alameda	0	0	90	0	0	6	0	0	4
415	1	Lower Foothills Metamorphic Belt	1	STANISLAUS RIVER	0	1	Calaveras	4	91	0	5	0	0	0	0	0
416	1	Lower Foothills Metamorphic Belt	2	STANISLAUS RIVER, UPPER CALAVERAS	0	2	Calaveras, Tuolumne	0	93	0	6	0	0	0	0	0
417	1	Lower Foothills Metamorphic Belt	2	GOPHER RIDGE, STANISLAUS RIVER	0	1	Calaveras	0	94	0	5	0	0	0	0	0
418	2	Camanche Terraces, Lower Foothills Metamorphic Belt	3	GOPHER RIDGE, NORTH VALLEY FLOOR, STANISLAUS RIVER	0	2	Calaveras, Stanislaus	0	37	58	3	1	1	0	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
419	Brushy Peak	174	0	509	113	509	85	21	19,249	78	22	21	1	78	228	11	12	16	0	24	5	97	2	7	1	GREAT CENTRAL VALLEY
420		260	83	462	105	379	82	9	7,044	29	16	16	0	84	246	7	2	1	0	0	0	0	0	6	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
421		202	17	393	72	376	0	0	2,587	10	92	92	0	8	280	17	18	9	100	23	1	0	0	0	1	CENTRAL COAST
422		509	377	694	68	317	83	17	3,692	15	0	0	0	100	265	3	0	0	0	0	0	100	1	0	1	SIERRA NEVADA
423		2,501	1,812	3,098	211	1,286	94	18	63,515	257	93	33	60	7	222	6	14	6	0	0	0	76	1	1	1	SIERRA NEVADA
424		190	27	373	71	346	2	10	3,957	16	95	95	0	5	269	4	6	5	14	6	1	0	1	1	1	CENTRAL COAST
425	Duck Creek North Fork	64	38	97	9	59	91	13	10,642	43	0	0	0	100	219	1	0	4	0	69	2	68	1	30	1	GREAT CENTRAL VALLEY
426	Cherokee Creek	380	281	601	57	320	73	22	8,238	33	0	0	0	100	245	1	0	0	0	0	0	100	1	0	1	SIERRA NEVADA
427		80	42	151	18	109	85	23	25,570	103	0	0	0	100	225	9	0	8	0	65	2	6	1	11	1	GREAT CENTRAL VALLEY
428		86	35	163	24	128	80	13	3,420	14	71	71	0	29	259	2	4	10	0	38	2	100	2	12	1	GREAT CENTRAL VALLEY
429		412	283	547	55	264	77	21	5,245	21	0	0	0	100	251	8	0	1	0	0	0	100	1	0	1	SIERRA NEVADA
430		287	73	617	109	544	37	40	16,053	65	87	87	0	13	258	4	6	4	12	94	1	13	1	0	1	CENTRAL COAST
431		304	153	485	71	332	0	0	2,323	9	99	99	0	1	267	5	10	5	100	49	1	0	0	1	1	CENTRAL COAST
432		261	60	657	120	597	12	30	5,365	22	94	94	0	6	256	2	12	6	2	53	1	78	1	0	1	CENTRAL COAST
433		2,471	253	3,814	604	3,561	85	22	793,060	3,209	99	95	3	1	177	38	39	38	0	4	1	8	2	3	1	SIERRA NEVADA
434		339	25	1,165	189	1,140	77	30	66,313	268	64	64	0	36	249	14	27	20	0	26	5	100	2	1	2	CENTRAL COAST, GREAT CENTRAL VALLEY
435	Bear Mountains	426	85	853	154	768	71	14	36,366	147	19	9	10	81	244	4	0	1	0	0	0	21	1	3	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
436		584	315	824	107	509	69	16	10,950	44	16	0	16	84	268	11	2	2	0	0	0	99	1	0	1	SIERRA NEVADA
437	Calaveras Big Trees	1,138	327	1,712	363	1,385	78	29	11,498	47	91	54	37	9	229	14	4	0	0	0	0	4	1	0	1	SIERRA NEVADA
438		601	373	816	95	443	70	11	2,892	12	41	0	41	59	263	10	1	0	0	0	0	23	1	0	1	SIERRA NEVADA
439		268	206	352	35	146	78	11	2,928	12	18	0	18	82	250	0	0	1	0	0	0	0	1	0	1	SIERRA NEVADA
440		228	36	514	103	478	66	35	17,547	71	50	50	0	50	265	3	11	9	0	0	1	99	1	0	2	CENTRAL COAST, GREAT CENTRAL VALLEY
441	Mandeville Island	-1	-3	1	1	4	10	24	5,834	24	88	88	0	12	230	3	6	2	0	100	1	0	0	5	1	GREAT CENTRAL VALLEY
442	Duck Creek	75	36	146	18	110	87	10	27,456	111	12	12	0	88	224	5	0	8	0	0	0	0	0	25	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
443		327	236	451	48	215	77	17	2,319	9	0	0	0	100	249	2	0	1	0	0	0	91	1	3	1	SIERRA NEVADA
444		131	1	336	73	335	53	41	7,343	30	100	100	0	0	320	5	5	11	100	0	2	70	1	3	1	CENTRAL COAST
445		455	248	758	108	510	71	14	7,442	30	21	0	21	79	261	11	2	1	0	0	0	0	0	0	1	SIERRA NEVADA
446	Briones Hills	225	48	444	82	396	26	34	14,603	59	94	94	0	6	268	4	6	6	100	95	2	25	1	0	1	CENTRAL COAST
447		-1	-3	3	1	6	2	11	2,840	11	98	96	2	2	235	0	4	1	0	100	1	0	0	1	1	GREAT CENTRAL VALLEY
448		122	66	218	29	152	79	7	2,490	10	7	7	1	93	238	8	2	1	0	0	0	0	0	0	1	SIERRA NEVADA
449		256	36	571	95	535	11	26	7,682	31	96	96	0	4	276	7	11	11	100	94	2	0	0	0	1	CENTRAL COAST
450		51	23	111	14	88	79	20	2,270	9	0	0	0	100	235	1	1	4	0	0	0	0	0	25	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
451		-1	-3	0	1	3	0	2	5,024	20	100	99	1	0	235	1	4	1	0	100	1	0	0	0	1	GREAT CENTRAL VALLEY
452		514	294	756	105	462	65	18	4,593	19	7	0	7	93	262	12	0	0	0	0	0	0	0	0	1	SIERRA NEVADA
453		205	4	487	102	483	56	32	3,692	15	100	100	0	0	310	11	19	4	100	78	1	100	1	5	1	CENTRAL COAST
454	Pine Ridge	963	599	1,779	174	1,180	78	21	38,492	156	42	16	26	58	231	12	2	1	0	0	0	44	1	0	1	SIERRA NEVADA
455		415	189	599	103	410	62	24	2,703	11	20	0	20	80	258	10	0	1	0	0	0	0	0	0	1	SIERRA NEVADA
456		182	41	337	61	296	52	38	5,627	23	57	57	0	43	274	2	1	2	100	87	1	65	1	0	1	CENTRAL COAST
457		306	169	523	78	354	85	16	20,610	83	2	0	2	98	249	2	0	2	0	0	0	0	0	0	1	SIERRA NEVADA
458		2,569	1,659	3,550	368	1,891	94	17	94,965	384	99	94	5	1	232	5	21	7	0	0	0	0	0	1	1	SIERRA NEVADA
459	Montezuma Hills	27	0	55	13	55	34	31	3,841	16	89	89	0	11	232	3	1	4	0	4	1	0	0	0	1	GREAT CENTRAL VALLEY
460		283	6	634	157	628	57	32	3,115	13	99	99	0	1	312	17	12	4	87	49	1	100	1	4	1	CENTRAL COAST
461		80	42	140	15	98	75	23	6,470	26	0	0	0	100	233	2	0	3	0	44	1	0	0	8	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
462		428	60	771	150	711	79	26	5,702	23	99	9	90	1	280	10	22	3	100	3	1	77	1	6	1	CENTRAL COAST
463		213	84	357	63	273	78	15	7,648	31	2	1	1	98	251	3	3	0	0	0	0	0	0	1	1	SIERRA NEVADA
464	Staten Island	-1	-2	5	1	7	0	4	10,216	41	93	93	0	7	233	1	7	3	0	100	1	0	0	0	1	GREAT CENTRAL VALLEY
465		121	3	321	77	318	36	43	2,319	9	89	89	0	11	288	3	4	6	100	0	0	0	0	3	1	CENTRAL COAST

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
419	3	Westside Alluvial Fans and Terraces, Fremont-Livermore Hills and Valleys, Eastern Hills	4	CARBONA, NORTH DIABLO RANGE, SAN JOAQUIN DELTA, SOUTH BAY	0	2	Contra Costa, Alameda	0	4	90	1	1	3	1	0	0
420	2	Camanche Terraces, Lower Foothills Metamorphic Belt	3	GOPHER RIDGE, NORTH VALLEY FLOOR, UPPER CALAVERAS	0	1	Calaveras	0	19	75	5	1	0	0	0	0
421	1	Leeward Hills	1	SOUTH BAY	0	1	San Mateo	3	75	3	0	0	19	0	0	0
422	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	2	STANISLAUS RIVER, UPPER CALAVERAS	0	1	Calaveras	7	84	0	8	0	0	0	0	0
423	2	Sweetwater Mountains-Pine Grove Hills, Bodie Hills-Excelsior Mountains	2	EAST WALKER RIVER, MONO	0	1	Mono	32	66	1	0	0	0	0	0	1
424	1	East Bay Hills-Mt. Diablo	1	SOUTH BAY	0	1	Alameda	18	60	3	1	1	17	0	0	0
425	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	1	San Joaquin	0	1	95	0	0	0	2	1	0
426	1	Lower Foothills Metamorphic Belt	1	UPPER CALAVERAS	0	1	Calaveras	0	92	0	8	0	0	0	0	0
427	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	3	Calaveras, San Joaquin, Stanislaus	0	3	92	1	0	2	1	1	0
428	3	Suisun Hills and Valleys, Westside Alluvial Fans and Terraces, Eastern Hills	2	NORTH DIABLO RANGE, SAN JOAQUIN DELTA	0	1	Contra Costa	0	0	96	1	0	2	1	0	0
429	1	Lower Foothills Metamorphic Belt	1	UPPER CALAVERAS	0	1	Calaveras	2	89	0	9	0	0	0	0	0
430	1	East Bay Hills-Mt. Diablo	2	SOUTH BAY, SUISUN	0	2	Contra Costa, Alameda	11	57	25	2	1	3	0	0	0
431	1	East Bay Hills-Mt. Diablo	1	SOUTH BAY	0	2	Contra Costa, Alameda	50	45	0	0	0	4	0	0	0
432	1	East Bay Hills-Mt. Diablo	2	NORTH DIABLO RANGE, SUISUN	0	1	Contra Costa	14	28	47	1	0	10	0	0	0
433	12	Glaciated Batholith, Eastern Slopes, Batholith and Volcanic Flows, Upper Batholith and Volcanic Flows, Upper Batholith, Glaciated Batholith and Volcanic Flows, Sweetwater Mountains-Pine Grove Hills, Upper Foothills Metamorphic Belt, and 4 others	6	EAST WALKER RIVER, MERCED RIVER, MONO, STANISLAUS RIVER, TUOLUMNE RIVER, WEST WALKER RIVER	0	4	Alpine, Mono, Tuolumne, Mariposa	55	8	0	4	1	0	0	0	32
434	3	East Bay Hills-Mt. Diablo, Fremont-Livermore Hills and Valleys, Eastern Hills	3	NORTH DIABLO RANGE, SOUTH BAY, SUISUN	0	2	Contra Costa, Alameda	13	26	56	1	2	2	0	0	0
435	2	Camanche Terraces, Lower Foothills Metamorphic Belt	4	GOPHER RIDGE, NORTH VALLEY FLOOR, STANISLAUS RIVER, UPPER CALAVERAS	0	1	Calaveras	1	72	21	6	0	0	0	0	0
436	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	UPPER CALAVERAS	0	1	Calaveras	29	63	0	7	0	0	0	0	0
437	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	2	STANISLAUS RIVER, UPPER CALAVERAS	0	2	Calaveras, Tuolumne	76	18	0	5	0	0	0	0	0
438	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	UPPER CALAVERAS	0	1	Calaveras	44	50	0	7	0	0	0	0	0
439	2	Camanche Terraces, Lower Foothills Metamorphic Belt	3	LOWER CALAVERAS, NORTH VALLEY FLOOR, UPPER CALAVERAS	0	1	Calaveras	0	55	6	5	2	0	0	0	33
440	3	Suisun Hills and Valleys, East Bay Hills-Mt. Diablo, Eastern Hills	3	NORTH DIABLO RANGE, SAN JOAQUIN DELTA, SUISUN	0	1	Contra Costa	4	32	58	0	0	4	0	0	0
441	1	Delta	1	SAN JOAQUIN DELTA	0	2	San Joaquin, Contra Costa	0	1	3	36	8	0	50	3	0
442	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	2	Calaveras, San Joaquin	0	6	87	1	0	1	5	1	0
443	1	Lower Foothills Metamorphic Belt	2	LOWER CALAVERAS, MIDDLE SIERRA	0	1	Calaveras	0	89	1	10	0	0	0	0	0
444	1	Marin Hills and Valleys	2	BAY BRIDGES, MARIN COASTAL	0	1	Marin	9	58	13	1	0	11	0	0	8
445	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, UPPER CALAVERAS	0	1	Calaveras	23	71	0	6	0	0	0	0	0
446	2	Suisun Hills and Valleys, East Bay Hills-Mt. Diablo	2	SAN PABLO, SUISUN	0	1	Contra Costa	5	49	37	3	2	3	0	0	0
447	1	Delta	1	SACRAMENTO DELTA	0	1	Sacramento	0	0	10	15	3	0	37	34	0
448	1	Camanche Terraces	2	MIDDLE SIERRA, NORTH VALLEY FLOOR	7	1	Amador	0	38	37	1	0	1	0	0	22
449	2	Bay Flats, East Bay Hills-Mt. Diablo	2	BAY BRIDGES, SAN PABLO	0	2	Contra Costa, Alameda	12	54	20	1	0	14	0	0	0
450	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	2	Amador, San Joaquin	0	11	74	8	2	2	1	1	0
451	1	Delta	2	SACRAMENTO DELTA, SAN JOAQUIN DELTA	0	1	Sacramento	0	0	3	1	0	4	84	7	0
452	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, UPPER CALAVERAS	0	1	Calaveras	30	64	0	5	0	0	0	0	0
453	1	Marin Hills and Valleys	1	MARIN COASTAL	0	1	Marin	41	37	6	0	0	6	0	0	9
454	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	2	MIDDLE SIERRA, UPPER CALAVERAS	0	1	Calaveras	69	25	0	6	0	0	0	0	0
455	1	Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, UPPER CALAVERAS	0	2	Amador, Calaveras	25	71	0	2	1	0	0	0	0
456	2	Suisun Hills and Valleys, East Bay Hills-Mt. Diablo	2	SAN PABLO, SUISUN	0	1	Contra Costa	0	28	68	1	0	3	0	0	0
457	2	Camanche Terraces, Lower Foothills Metamorphic Belt	3	LOWER CALAVERAS, MIDDLE SIERRA, NORTH VALLEY FLOOR	0	2	Amador, Calaveras	0	89	2	5	3	0	0	0	0
458	5	Eastern Slopes, Pine Nut Mountains, Antelope-Mason Valleys and Hills, Sweetwater Mountains-Pine Grove Hills, Bodie Hills-Excelsior Mountains	2	EAST WALKER RIVER, WEST WALKER RIVER	0	1	Mono	66	22	0	1	0	0	0	0	10
459	2	Sodic Claypan Terraces, Delta	2	SACRAMENTO DELTA, VALLEY PUTAH-CACHE	0	2	Sacramento, Solano	0	0	24	1	4	2	5	64	0
460	1	Marin Hills and Valleys	1	MARIN COASTAL	0	1	Marin	47	28	10	0	0	7	0	0	8
461	1	Camanche Terraces	1	NORTH VALLEY FLOOR	0	2	Amador, San Joaquin	0	3	84	3	0	3	0	0	7
462	1	Marin Hills and Valleys	2	BAY BRIDGES, MARIN COASTAL	0	1	Marin	63	26	1	0	0	7	0	0	2
463	2	Camanche Terraces, Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, NORTH VALLEY FLOOR	1	1	Amador	0	74	21	3	1	1	0	0	0
464	2	Sodic Claypan Terraces, Delta	2	SACRAMENTO DELTA, SAN JOAQUIN DELTA	0	2	Sacramento, San Joaquin	0	0	1	1	4	1	93	0	0
465	2	Marin Hills and Valleys, Mount St. Helena Flows and Valleys	2	BAY BRIDGES, SAN PABLO	0	1	Marin	37	39	5	1	0	17	0	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
466	Bear Slough	4	0	8	2	8	52	36	4,277	17	87	86	2	13	228	2	1	3	0	52	1	0	0	41	1	GREAT CENTRAL VALLEY
467	Hopkins Ravine	47	8	83	14	75	85	24	5,849	24	0	0	0	100	225	2	3	2	0	0	0	37	1	1	1	GREAT CENTRAL VALLEY
468		1	0	6	1	6	8	19	3,228	13	94	83	11	6	232	1	8	3	0	100	1	0	0	13	1	GREAT CENTRAL VALLEY
469		277	153	383	43	230	81	20	3,023	12	0	0	0	100	247	1	0	0	0	0	0	0	0	1	1	SIERRA NEVADA
470	Lightning Mountain	2,447	1,395	3,478	349	2,083	80	20	280,220	1,134	100	98	2	0	180	27	12	16	0	0	0	0	0	3	1	SIERRA NEVADA
471	Dry Creek	74	32	184	21	152	81	25	32,098	130	40	40	0	60	227	4	4	9	0	57	4	37	1	30	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
472		250	71	483	84	412	16	32	2,979	12	84	84	0	16	273	4	3	2	100	0	0	76	1	3	1	CENTRAL COAST
473		8	4	12	2	8	44	32	3,938	16	95	91	4	5	227	1	3	7	0	0	0	0	0	57	1	GREAT CENTRAL VALLEY
474		168	13	348	63	335	32	26	8,508	34	54	54	0	46	260	2	0	6	85	26	1	100	1	0	1	CENTRAL COAST
475		232	5	537	109	532	63	37	20,980	85	96	59	37	4	277	10	23	22	91	4	1	91	1	3	1	CENTRAL COAST
476		14	8	19	3	11	77	25	2,954	12	92	92	0	8	226	0	1	7	0	0	0	0	0	81	1	GREAT CENTRAL VALLEY
477		156	79	237	30	158	85	12	5,798	23	0	0	0	100	248	4	2	1	0	0	0	15	1	1	1	SIERRA NEVADA
478		706	498	889	79	391	67	19	4,759	19	12	0	12	88	244	20	1	1	0	0	0	2	1	0	1	SIERRA NEVADA
479	Irish Hill	116	60	196	37	136	87	16	6,354	26	1	1	0	99	251	3	6	0	0	3	3	56	2	2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
480		168	19	440	73	421	69	31	8,221	33	61	60	0	39	270	3	11	13	100	21	1	100	1	2	1	CENTRAL COAST
481		7	0	28	5	28	84	25	7,220	29	22	22	0	78	227	2	9	6	0	58	1	91	1	71	1	GREAT CENTRAL VALLEY
482	Grizzly Island	6	0	127	15	127	92	15	61,327	248	22	6	15	78	242	9	18	20	2	82	7	16	1	71	1	GREAT CENTRAL VALLEY
483		1,365	1,172	1,609	92	437	62	16	3,094	13	94	0	94	6	214	3	1	0	0	0	0	97	1	0	1	SIERRA NEVADA
484		38	26	49	5	23	67	25	2,608	11	8	8	0	92	224	1	0	1	0	82	3	83	1	66	1	GREAT CENTRAL VALLEY
485	Quartz Mountain	455	191	660	95	469	75	19	17,737	72	6	0	6	94	260	10	0	2	0	0	0	1	1	0	1	SIERRA NEVADA
486		2	0	33	3	33	38	35	2,760	11	88	86	2	12	273	11	0	8	0	0	0	0	0	30	1	CENTRAL COAST
487		277	197	371	44	174	67	25	2,554	10	0	0	0	100	250	2	0	1	0	0	0	99	1	1	1	SIERRA NEVADA
488		74	0	182	47	182	79	33	2,329	9	99	99	0	1	289	23	7	12	100	0	1	100	1	6	1	CENTRAL COAST
489		161	49	289	45	240	51	26	3,395	14	66	66	0	34	254	2	2	1	0	0	0	100	1	0	1	CENTRAL COAST
490	Stone Lake	2	0	7	1	7	7	18	7,847	32	96	96	0	4	231	2	1	4	0	91	1	0	0	10	1	GREAT CENTRAL VALLEY
491		112	62	185	32	123	78	25	4,926	20	1	0	1	99	250	8	5	0	0	0	0	55	2	2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
492		500	367	626	59	259	71	19	2,858	12	1	0	1	99	265	9	0	0	0	0	0	81	1	3	1	SIERRA NEVADA
493		833	522	1,264	148	742	72	21	21,580	87	6	0	6	94	240	21	3	1	0	0	0	92	1	0	1	SIERRA NEVADA
494	Browns Creek	58	31	107	13	76	83	20	31,664	128	21	18	3	79	227	6	2	9	0	57	4	81	1	30	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
495		203	20	565	106	545	54	39	16,720	68	67	67	0	33	269	4	9	5	100	0	0	61	1	2	1	CENTRAL COAST
496		16	0	53	11	53	81	27	20,259	82	27	25	1	73	224	5	18	14	0	29	7	99	1	73	1	GREAT CENTRAL VALLEY
497		2,039	1,584	2,467	217	883	97	11	8,243	33	99	94	5	1	235	7	0	0	0	0	0	0	0	0	1	SIERRA NEVADA
498		1	0	3	0	3	39	34	10,269	42	91	82	9	9	255	8	2	10	0	0	0	0	0	20	1	CENTRAL COAST
499		153	0	427	98	427	69	29	33,274	135	97	97	0	3	313	13	32	30	64	47	3	100	1	5	1	CENTRAL COAST
500		4	-6	91	11	97	46	32	5,149	21	90	31	59	10	268	13	4	8	1	0	0	22	1	62	1	CENTRAL COAST
501	Little Holland Tract/ Yolo Bypass	2	0	9	1	9	76	23	2,147	9	28	28	0	72	232	2	0	0	0	100	1	0	0	75	1	GREAT CENTRAL VALLEY
502		2	0	5	1	5	61	38	2,908	12	93	62	31	7	230	1	1	8	0	97	1	0	0	74	1	GREAT CENTRAL VALLEY
503		182	3	475	90	472	65	26	10,189	41	33	33	0	67	260	3	6	5	49	0	0	1	1	1	1	CENTRAL COAST
504	Tolay Creek	80	1	246	44	245	40	30	6,445	26	61	61	0	39	258	8	0	6	0	0	0	100	1	0	1	CENTRAL COAST
505		141	57	250	36	193	66	35	11,871	48	14	14	0	86	249	3	2	1	0	0	0	99	1	2	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
506		2,282	867	3,155	361	2,288	77	21	182,273	738	98	91	8	2	178	24	5	13	0	0	0	0	0	2	1	SIERRA NEVADA
507		3	0	7	2	7	2	7	2,023	8	93	93	0	7	230	2	2	14	0	25	1	5	1	18	1	GREAT CENTRAL VALLEY
508		155	8	460	71	452	82	21	23,151	94	43	39	4	57	287	24	8	8	100	30	3	100	1	2	1	CENTRAL COAST
509		128	42	331	59	289	72	25	3,688	15	44	44	0	56	263	1	0	2	67	12	2	44	1	2	1	CENTRAL COAST
510	Lake Marie	240	12	574	121	562	68	25	12,520	51	38	38	0	62	266	7	7	1	0	2	1	70	2	0	2	CENTRAL COAST, NORTH COAST
511	Middle Fork Cosumnes River	502	238	685	85	447	60	18	13,195	53	12	3	9	88	260	8	0	0	0	0	0	100	1	0	1	SIERRA NEVADA
512	Big Mountain Ridge	1,003	509	1,446	246	937	64	20	14,590	59	59	0	59	41	224	6	2	1	0	0	0	100	1	0	1	SIERRA NEVADA

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
466	2	Hardpan Terraces, Sodic Claypan Terraces	4	NORTH VALLEY FLOOR, SACRAMENTO DELTA, SAN JOAQUIN DELTA, VALLEY-AMERICAN	23	2	Sacramento, San Joaquin	0	2	26	46	1	1	24	1	0
467	1	Sodic Claypan Terraces	2	SUISUN, VALLEY PUTAH-CACHE	0	1	Solano	0	1	86	2	0	2	3	7	0
468	1	Sodic Claypan Terraces	2	SACRAMENTO DELTA, SAN JOAQUIN DELTA	0	2	Sacramento, San Joaquin	0	1	2	20	4	1	72	0	0
469	1	Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	Amador	0	80	15	4	0	0	0	0	0
470	8	Upper Batholith and Volcanic Flows, Upper Batholith and Volcanic Flows, Glaciated Batholith and Volcanic Flows, Batholith and Volcanic Flows, Eastern Slopes, Pine Nut Mountains, Antelope-Mason Valleys and Hills, Sweetwater Mountains-Pine Grove Hills	4	EAST FORK CARSON RIVER, MIDDLE SIERRA, STANISLAUS RIVER, WEST WALKER RIVER	6	4	Alpine, Mono, Calaveras, Tuolumne	75	10	0	4	0	0	0	0	11
471	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	3	Sacramento, Amador, San Joaquin	0	5	88	2	1	2	2	1	0
472	1	Marin Hills and Valleys	3	BAY BRIDGES, MARIN COASTAL, SAN PABLO	0	1	Marin	30	28	37	0	0	3	0	0	2
473	2	Hardpan Terraces, Sodic Claypan Terraces	1	NORTH VALLEY FLOOR	0	1	Sacramento	0	1	48	15	1	0	33	3	0
474	2	Suisun Hills and Valleys, Delta	2	SAN PABLO, SUISUN	0	2	Napa, Solano	0	10	84	1	0	3	0	0	1
475	1	Marin Hills and Valleys	2	BAY BRIDGES, MARIN COASTAL	0	1	Marin	53	25	14	0	1	5	0	0	2
476	1	Hardpan Terraces	1	NORTH VALLEY FLOOR	0	1	Sacramento	0	1	78	8	1	2	9	3	0
477	2	Camanche Terraces, Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, NORTH VALLEY FLOOR	0	1	Amador	0	35	59	5	0	1	0	0	0
478	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	Amador	58	36	0	6	0	0	0	0	0
479	2	Camanche Terraces, Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, NORTH VALLEY FLOOR	1	1	Amador	0	37	56	6	0	0	0	0	0
480	1	Marin Hills and Valleys	1	MARIN COASTAL	0	1	Marin	38	26	31	1	0	3	0	0	1
481	2	Yolo-American Basins, Sodic Claypan Terraces	2	SACRAMENTO DELTA, VALLEY PUTAH-CACHE	0	1	Solano	0	0	86	8	0	2	4	0	0
482	3	Suisun Hills and Valleys, Sodic Claypan Terraces, Delta	1	SUISUN	0	1	Solano	0	1	30	60	5	1	2	1	0
483	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	1	MIDDLE SIERRA	0	1	El Dorado	89	0	0	11	0	0	0	0	0
484	1	Hardpan Terraces	1	NORTH VALLEY FLOOR	0	1	Sacramento	0	0	86	0	1	0	3	9	0
485	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	Amador	8	84	0	7	0	0	0	0	0
486	2	Coastal Hills-Santa Rosa Plain, Mount St. Helena Flows and Valleys	1	SAN PABLO	0	2	Sonoma, Marin	0	0	64	21	8	5	0	0	1
487	1	Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	Amador	0	68	15	6	0	1	0	0	10
488	1	Marin Hills and Valleys	1	MARIN COASTAL	0	1	Marin	8	25	61	4	0	1	0	0	1
489	1	Suisun Hills and Valleys	2	SAN PABLO, SUISUN	0	2	Napa, Solano	1	8	88	0	0	2	0	0	1
490	3	Hardpan Terraces, Yolo-American Basins, Sodic Claypan Terraces	2	SACRAMENTO DELTA, VALLEY-AMERICAN	0	1	Sacramento	0	1	7	12	2	1	67	10	0
491	2	Camanche Terraces, Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, NORTH VALLEY FLOOR	0	2	Sacramento, Amador	0	36	61	1	0	1	0	0	0
492	1	Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	Amador	4	89	0	5	0	0	2	1	0
493	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	2	El Dorado, Amador	60	32	0	7	0	0	0	0	0
494	2	Hardpan Terraces, Camanche Terraces	1	NORTH VALLEY FLOOR	0	2	Sacramento, Amador	0	2	91	1	0	2	3	1	0
495	2	Marin Hills and Valleys, Mount St. Helena Flows and Valleys	2	MARIN COASTAL, SAN PABLO	0	1	Marin	23	33	40	1	0	2	0	0	1
496	1	Sodic Claypan Terraces	3	SACRAMENTO DELTA, SUISUN, VALLEY PUTAH-CACHE	0	1	Solano	0	0	90	3	0	2	4	1	0
497	2	Eastern Slopes, Pine Nut Mountains	1	EAST FORK CARSON RIVER	0	1	Alpine	90	7	0	2	0	0	0	0	1
498	1	Mount St. Helena Flows and Valleys	1	SAN PABLO	0	3	Sonoma, Napa, Solano	0	1	60	26	11	2	0	0	1
499	1	Marin Hills and Valleys	1	MARIN COASTAL	0	1	Marin	45	34	14	2	0	2	0	0	3
500	3	Coastal Hills-Santa Rosa Plain, Marin Hills and Valleys, Mount St. Helena Flows and Valleys	1	SAN PABLO	0	2	Sonoma, Marin	2	5	34	51	4	2	0	0	1
501	1	Yolo-American Basins	1	SACRAMENTO DELTA	0	1	Yolo	0	2	19	53	2	1	15	8	0
502	3	Hardpan Terraces, Yolo-American Basins, Sodic Claypan Terraces	2	SACRAMENTO DELTA, VALLEY-AMERICAN	0	1	Sacramento	0	1	66	19	4	1	9	0	0
503	2	Marin Hills and Valleys, Mount St. Helena Flows and Valleys	2	MARIN COASTAL, SAN PABLO	0	1	Marin	3	48	45	0	0	1	0	0	2
504	2	Coastal Hills-Santa Rosa Plain, Mount St. Helena Flows and Valleys	1	SAN PABLO	0	1	Sonoma	2	3	85	0	0	1	9	0	1
505	2	Camanche Terraces, Lower Foothills Metamorphic Belt	2	MIDDLE SIERRA, NORTH VALLEY FLOOR	0	3	El Dorado, Sacramento, Amador	0	27	69	2	0	1	0	0	1
506	7	Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Glaciated Batholith and Volcanic Flows, Batholith and Volcanic Flows, Eastern Slopes, Carson Range, Carson Valley-Truckee Meadows	5	AMERICAN RIVER, EAST FORK CARSON RIVER, MIDDLE SIERRA, STANISLAUS RIVER, WEST FORK CARSON RIVER	0	3	Alpine, Amador, Calaveras	69	14	0	5	0	0	0	0	12
507	3	Hardpan Terraces, Yolo-American Basins, Sodic Claypan Terraces	2	SACRAMENTO DELTA, VALLEY-AMERICAN	0	1	Sacramento	0	1	50	20	3	11	15	0	0
508	1	Marin Hills and Valleys	1	MARIN COASTAL	0	1	Marin	5	38	54	0	0	1	0	0	1
509	2	Coastal Hills-Santa Rosa Plain, Marin Hills and Valleys	2	MARIN COASTAL, SAN PABLO	0	2	Sonoma, Marin	2	23	74	0	0	0	0	0	1
510	2	Suisun Hills and Valleys, Mount St. Helena Flows and Valleys	2	SAN PABLO, SUISUN	0	2	Napa, Solano	2	42	48	1	1	3	2	0	2
511	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	2	El Dorado, Amador	13	79	0	8	0	0	0	0	0
512	3	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	El Dorado	73	19	0	7	0	0	0	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
513		489	295	708	90	413	53	14	3,350	14	35	34	1	65	272	8	0	0	0	0	0	100	1	0	1	SIERRA NEVADA
514		59	40	77	7	37	78	15	2,877	12	0	0	0	100	228	0	1	5	0	0	0	99	1	95	1	GREAT CENTRAL VALLEY
515	Yolo Bypass	3	0	8	1	8	83	25	7,628	31	83	35	48	17	229	2	4	6	0	100	1	0	0	60	1	GREAT CENTRAL VALLEY
516	Logtown Ridge	289	109	550	90	441	69	14	27,101	110	11	4	6	89	249	1	0	1	0	0	0	100	1	0	1	SIERRA NEVADA
517	Sturdevant Ridge	1,133	667	1,624	205	957	63	19	17,100	69	59	0	59	41	221	3	1	5	0	0	0	99	1	0	1	SIERRA NEVADA
518		1,379	1,138	1,563	93	425	76	21	4,046	16	87	0	87	13	213	3	1	1	0	0	0	99	1	0	1	SIERRA NEVADA
519		2,353	1,696	3,045	248	1,349	69	22	43,741	177	100	91	9	0	176	12	7	11	0	0	0	0	0	4	1	SIERRA NEVADA
520		60	38	83	10	45	82	18	4,415	18	0	0	0	100	227	1	1	1	0	0	0	44	1	31	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
521		214	93	528	85	435	89	5	3,151	13	95	95	0	5	254	1	0	0	0	0	0	0	0	3	1	NORTH COAST
522	Coyote Creek	65	32	104	17	72	88	15	13,688	55	11	2	9	89	239	10	2	8	0	0	0	53	2	18	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
523		113	51	171	22	120	91	12	6,033	24	7	0	7	93	249	3	1	4	0	0	0	90	2	7	1	SIERRA NEVADA
524		1,378	1,190	1,573	80	383	66	18	2,861	12	22	0	22	78	209	3	1	0	0	0	0	98	1	0	1	SIERRA NEVADA
525		142	47	343	51	296	76	27	14,494	59	16	12	4	84	246	4	1	2	0	0	0	97	1	4	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
526		58	0	201	38	201	74	35	18,977	77	100	100	0	0	316	3	44	18	70	49	3	100	1	5	1	CENTRAL COAST
527	Chileno Valley	136	4	420	67	416	82	21	32,289	131	42	42	0	58	273	16	10	8	100	40	3	85	1	2	1	CENTRAL COAST
528	Marble Valley	270	153	396	57	243	71	14	6,756	27	9	9	0	91	247	1	1	1	0	0	0	100	1	0	1	SIERRA NEVADA
529		391	114	592	83	478	79	10	2,303	9	93	93	0	7	255	1	5	0	0	22	1	99	1	0	1	NORTH COAST
530		54	5	135	34	130	74	24	2,226	9	59	59	0	41	268	5	4	3	100	0	0	34	1	2	1	CENTRAL COAST
531		19	7	59	6	52	0	0	2,497	10	92	92	0	8	229	0	0	8	0	18	1	0	0	38	1	GREAT CENTRAL VALLEY
532	English Hills	59	34	115	13	81	76	10	3,400	14	0	0	0	100	237	10	1	1	0	0	0	0	0	5	2	GREAT CENTRAL VALLEY, NORTH COAST
533		2,532	1,521	3,311	301	1,790	74	25	40,357	163	99	93	7	1	220	15	5	6	0	0	0	0	0	2	1	SIERRA NEVADA
534		77	6	150	34	144	65	23	3,004	12	13	13	0	87	259	1	4	1	100	0	0	0	0	2	1	CENTRAL COAST
535	Sacramento Bypass	4	2	9	1	7	4	13	4,019	16	94	93	1	6	233	1	0	3	0	0	1	0	0	5	1	GREAT CENTRAL VALLEY
536		71	-2	185	47	187	71	28	5,147	21	42	42	0	58	286	20	11	5	71	14	2	87	1	3	1	CENTRAL COAST
537		1,021	575	1,467	213	892	77	31	6,173	25	97	20	78	3	216	4	3	2	0	0	0	0	0	0	1	SIERRA NEVADA
538		79	4	281	46	277	61	19	5,014	20	27	27	0	73	267	7	4	3	100	0	0	0	0	2	1	CENTRAL COAST
539	Bennett Mountain	268	70	575	99	505	0	2	5,663	23	96	96	0	4	248	4	8	3	18	0	0	31	2	1	1	NORTH COAST
540	Mt Hood	499	125	829	140	704	57	25	9,390	38	95	94	0	5	250	1	6	1	0	0	0	9	2	0	1	NORTH COAST
541		204	58	520	101	462	75	25	2,350	10	93	93	0	7	260	0	3	5	0	0	0	0	0	1	1	NORTH COAST
542		313	142	489	77	347	57	19	7,154	29	59	35	24	41	254	2	8	1	0	0	0	0	0	0	1	SIERRA NEVADA
543		334	142	541	70	399	73	16	2,900	12	1	1	0	99	254	1	0	2	0	0	0	0	0	0	1	SIERRA NEVADA
544		376	208	607	78	399	75	14	3,965	16	2	0	2	98	254	4	1	0	0	0	0	0	0	0	1	SIERRA NEVADA
545	Curry Creek	28	20	37	4	17	75	12	4,021	16	0	0	0	100	224	2	1	3	0	0	0	64	1	62	1	GREAT CENTRAL VALLEY
546		164	0	433	95	433	55	21	8,403	34	97	97	0	3	288	19	3	7	3	0	0	0	0	0	2	CENTRAL COAST, NORTH COAST
547		353	137	499	101	362	18	25	4,591	19	90	88	2	10	257	7	2	1	0	0	0	0	0	0	1	SIERRA NEVADA
548		445	144	721	150	577	91	5	8,138	33	79	78	2	21	242	5	4	3	0	0	0	13	1	0	1	NORTH COAST
549		354	164	517	94	353	0	0	2,057	8	96	95	0	4	269	2	2	1	0	0	0	0	0	0	1	SIERRA NEVADA
550		579	163	862	133	699	64	14	3,610	15	94	92	2	6	256	3	2	0	0	0	0	34	1	0	1	NORTH COAST
551	Dunnigan Hills/ Smith Creek	55	21	84	13	63	90	15	9,135	37	0	0	0	100	215	9	0	2	0	0	0	0	0	1	1	GREAT CENTRAL VALLEY
552		399	164	705	119	541	9	11	8,026	32	93	92	2	7	257	19	2	2	0	0	0	0	0	0	1	SIERRA NEVADA
553		295	65	471	87	406	78	13	3,224	13	93	93	0	7	255	10	6	2	100	0	0	24	1	0	1	NORTH COAST
554		448	211	704	116	493	7	3	2,453	10	94	90	4	6	242	20	0	1	0	0	0	0	0	0	1	SIERRA NEVADA
555	Coon Creek	29	24	36	2	12	80	21	2,028	8	46	46	0	54	221	1	0	0	0	0	0	78	1	74	1	GREAT CENTRAL VALLEY
556		838	344	1,257	191	913	82	19	3,694	15	94	94	0	6	259	2	15	1	100	0	0	31	1	0	1	NORTH COAST
557		44	29	77	10	48	72	18	4,480	18	16	16	0	84	242	10	1	2	0	0	0	89	1	76	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
558		834	425	1,160	183	735	86	11	4,379	18	29	0	29	71	221	3	0	2	0	0	0	0	0	0	1	SIERRA NEVADA
559		631	276	898	153	622	60	36	3,251	13	56	38	18	44	226	1	1	1	0	0	0	0	0	0	1	SIERRA NEVADA
560	Dunnigan Hills	76	19	135	22	116	89	22	15,107	61	0	0	0	100	220	5	2	2	0	3	1	0	0	1	1	GREAT CENTRAL VALLEY
561		181	13	330	67	317	70	29	3,197	13	96	96	0	4	310	1	7	3	0	85	1	0	0	0	1	NORTH COAST
562		84	39	159	29	120	78	11	2,334	9	10	10	0	90	252	0	0	0	0	0	0	0	0	27	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
563	Bear River	246	82	511	89	429	77	8	8,734	35	14	11	3	86	248	2	0	1	0	0	0	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
564		2,099	1,817	2,557	134	740	80	21	8,778	36	80	22	59	20	211	5	2	7	0	0	0	0	0	1	1	SIERRA NEVADA
565		347	42	746	137	704	84	27	33,419	135	23	23	1	77	247	3	9	4	0	17	1	0	0	0	1	NORTH COAST
566	The Cedars/ Adams Ridge	362	133	746	120	613	97	8	76,638	310	46	7	39	54	243	4	18	11	0	0	0	65	2	0	1	NORTH COAST

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
513	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	El Dorado	20	72	0	7	0	2	0	0	0
514	1	Hardpan Terraces	1	VALLEY-AMERICAN	0	1	Sacramento	0	0	91	0	0	2	0	0	7
515	2	Yolo Alluvial Fans, Yolo-American Basins	1	SACRAMENTO DELTA	0	1	Yolo	0	1	16	70	0	0	10	2	0
516	1	Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	2	El Dorado, Amador	0	84	10	5	0	0	0	0	0
517	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	1	MIDDLE SIERRA	0	1	El Dorado	88	4	0	6	0	0	0	0	1
518	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	1	MIDDLE SIERRA	0	1	El Dorado	89	0	0	6	0	0	0	0	4
519	4	Upper Batholith and Volcanic Flows, Glaciated Batholith and Volcanic Flows, Tahoe Valley, Eastern Slopes	4	AMERICAN RIVER, LAKE TAHOE, MIDDLE SIERRA, WEST FORK CARSON RIVER	0	3	El Dorado, Alpine, Amador	74	14	0	7	0	0	0	0	6
520	1	Hardpan Terraces	1	VALLEY-AMERICAN	0	1	Sacramento	0	9	80	3	0	2	5	0	0
521	2	Ultramafic Complex, Western Foothills	1	SUISUN	0	1	Napa	1	74	9	3	9	1	0	0	1
522	3	Hardpan Terraces, Camanche Terraces, Lower Foothills Metamorphic Belt	3	MIDDLE SIERRA, NORTH VALLEY FLOOR, VALLEY-AMERICAN	0	1	Sacramento	0	6	91	1	0	0	1	1	0
523	3	Hardpan Terraces, Camanche Terraces, Lower Foothills Metamorphic Belt	3	AMERICAN RIVER, MIDDLE SIERRA, NORTH VALLEY FLOOR	0	1	Sacramento	0	4	92	1	0	4	0	0	0
524	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	2	AMERICAN RIVER, MIDDLE SIERRA	0	1	El Dorado	88	2	0	6	0	0	0	0	4
525	2	Camanche Terraces, Lower Foothills Metamorphic Belt	3	AMERICAN RIVER, MIDDLE SIERRA, NORTH VALLEY FLOOR	0	2	El Dorado, Sacramento	0	21	73	2	0	2	0	0	2
526	1	Marin Hills and Valleys	1	MARIN COASTAL	0	1	Marin	12	18	59	2	1	2	0	0	6
527	2	Coastal Hills-Santa Rosa Plain, Marin Hills and Valleys	3	BODEGA, MARIN COASTAL, SAN PABLO	0	2	Sonoma, Marin	4	38	57	1	0	1	0	0	1
528	1	Lower Foothills Metamorphic Belt	1	MIDDLE SIERRA	0	1	El Dorado	0	52	43	3	0	1	0	0	0
529	1	Mount St. Helena Flows and Valleys	2	SAN PABLO, SUISUN	0	1	Napa	3	88	5	1	1	1	0	0	1
530	1	Coastal Hills-Santa Rosa Plain	2	BODEGA, MARIN COASTAL	0	1	Marin	1	3	93	0	0	2	0	0	1
531	1	Hardpan Terraces	1	VALLEY-AMERICAN	0	1	Sacramento	0	8	24	21	15	20	12	0	0
532	3	Suisun Hills and Valleys, Yolo Alluvial Fans, Sodic Claypan Terraces	1	VALLEY PUTAH-CACHE	0	1	Solano	0	3	93	0	0	3	1	0	0
533	5	Glaciated Batholith and Volcanic Flows, Tahoe Valley, Eastern Slopes, Carson Range, Carson Valley-Truckee Meadows	2	LAKE TAHOE, WEST FORK CARSON RIVER	0	2	El Dorado, Alpine	71	8	0	3	0	0	1	0	16
534	1	Coastal Hills-Santa Rosa Plain	1	BODEGA	0	2	Sonoma, Marin	1	3	93	0	0	2	0	0	0
535	2	Yolo Alluvial Fans, Yolo-American Basins	2	SACRAMENTO DELTA, VALLEY PUTAH-CACHE	0	1	Yolo	0	0	6	4	2	1	81	6	0
536	1	Coastal Hills-Santa Rosa Plain	2	BODEGA, MARIN COASTAL	0	2	Sonoma, Marin	1	13	80	2	1	1	0	0	2
537	2	Upper Foothills Metamorphic Belt, Batholith and Volcanic Flows	1	AMERICAN RIVER	0	1	El Dorado	87	6	0	6	0	0	0	0	1
538	1	Coastal Hills-Santa Rosa Plain	2	BODEGA, RUSSIAN RIVER	0	1	Sonoma	3	9	85	1	0	1	0	0	1
539	1	Mount St. Helena Flows and Valleys	2	RUSSIAN RIVER, SAN PABLO	0	1	Sonoma	47	34	10	1	2	6	0	0	0
540	1	Mount St. Helena Flows and Valleys	2	RUSSIAN RIVER, SAN PABLO	0	2	Sonoma, Napa	55	38	4	0	0	1	0	0	2
541	2	Mount St. Helena Flows and Valleys, Ultramafic Complex	1	SAN PABLO	0	1	Napa	30	37	21	4	5	0	0	0	2
542	1	Lower Foothills Metamorphic Belt	1	AMERICAN RIVER	28	1	El Dorado	0	94	0	5	0	0	0	0	0
543	1	Lower Foothills Metamorphic Belt	1	AMERICAN RIVER	0	1	El Dorado	0	97	0	2	0	1	0	0	0
544	1	Lower Foothills Metamorphic Belt	1	AMERICAN RIVER	0	1	El Dorado	3	91	0	6	0	0	0	0	0
545	1	Hardpan Terraces	1	VALLEY-AMERICAN	0	1	Placer	0	1	74	0	0	0	24	1	0
546	2	Coastal Franciscan, Coastal Hills-Santa Rosa Plain	2	BODEGA, RUSSIAN RIVER	0	1	Sonoma	48	23	23	1	1	3	0	0	1
547	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	AMERICAN RIVER	0	2	Placer, El Dorado	3	89	0	5	1	2	0	0	0
548	1	Ultramafic Complex	1	PUTAH CREEK	75	1	Napa	17	79	4	0	0	0	0	0	0
549	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	AMERICAN RIVER	0	1	Placer	18	70	0	7	5	1	0	0	0
550	2	Mount St. Helena Flows and Valleys, Ultramafic Complex	2	PUTAH CREEK, SAN PABLO	0	1	Napa	48	50	1	0	0	1	0	0	0
551	2	Yolo Alluvial Fans, Dunnigan Hills	2	COLUSA BASIN, VALLEY PUTAH-CACHE	0	1	Yolo	0	1	79	1	0	1	16	2	0
552	2	Upper Foothills Metamorphic Belt, Lower Foothills Metamorphic Belt	1	AMERICAN RIVER	0	2	Placer, El Dorado	24	70	0	5	1	1	0	0	0
553	2	Mount St. Helena Flows and Valleys, Central Franciscan	1	RUSSIAN RIVER	0	1	Sonoma	36	43	19	0	0	1	0	0	1
554	1	Upper Foothills Metamorphic Belt	1	AMERICAN RIVER	0	1	Placer	45	49	0	5	1	0	0	0	0
555	1	Hardpan Terraces	1	VALLEY-AMERICAN	0	1	Placer	0	0	82	3	0	2	6	5	0
556	1	Mount St. Helena Flows and Valleys	3	PUTAH CREEK, RUSSIAN RIVER, SAN PABLO	0	3	Lake, Sonoma, Napa	65	33	2	0	0	0	0	0	0
557	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	3	AMERICAN RIVER, MARYSVILLE, VALLEY-AMERICAN	0	1	Placer	0	1	82	6	0	1	4	6	0
558	1	Upper Foothills Metamorphic Belt	1	AMERICAN RIVER	0	1	Placer	86	4	0	9	0	0	0	0	1
559	1	Upper Foothills Metamorphic Belt	1	AMERICAN RIVER	0	1	Placer	67	25	0	7	0	0	0	0	1
560	2	Yolo Alluvial Fans, Dunnigan Hills	2	COLUSA BASIN, VALLEY PUTAH-CACHE	0	1	Yolo	0	3	84	0	0	0	9	4	0
561	1	Coastal Franciscan	1	MENDOCINO COAST	0	1	Sonoma	97	2	1	0	0	0	0	0	0
562	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	2	BEAR RIVER, MARYSVILLE	0	1	Placer	0	26	70	2	0	1	0	0	0
563	1	Lower Foothills Metamorphic Belt	2	AMERICAN RIVER, BEAR RIVER	0	3	Yuba, Nevada, Placer	0	90	2	7	0	0	0	0	0
564	1	Tahoe-Truckee	2	LAKE TAHOE, TRUCKEE RIVER	0	1	Placer	93	1	0	5	0	1	0	0	0
565	1	Coastal Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	4	1	Sonoma	42	38	7	0	0	1	0	0	11
566	3	Central Franciscan, Ultramafic Complex, Western Foothills	1	PUTAH CREEK	4	2	Lake, Napa	20	68	11	0	0	0	0	0	1

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
567	Mosquito Ridge/ Crystal Ridge	1,881	246	3,034	584	2,788	82	22	277,370	1,122	88	59	30	12	193	17	23	24	0	0	0	0	1	1	1	SIERRA NEVADA
568		1,969	1,805	2,269	121	464	0	0	2,282	9	92	89	3	8	211	1	1	5	0	0	0	0	0	2	1	SIERRA NEVADA
569		2,010	1,634	2,412	192	778	69	15	2,333	9	82	72	11	18	214	1	0	1	0	0	0	0	0	0	1	SIERRA NEVADA
570	Blue Ridge/ Rocky Ridge	384	42	918	190	876	95	11	123,280	499	39	13	26	61	237	8	10	10	0	0	0	40	1	0	2	GREAT CENTRAL VALLEY, NORTH COAST
571		1,935	1,669	2,141	96	472	83	20	2,780	11	85	6	79	15	214	1	0	0	0	0	0	0	0	0	1	SIERRA NEVADA
572	Sawtooth Ridge	1,535	544	2,437	403	1,893	87	17	81,647	330	71	41	31	29	196	13	4	11	0	0	0	0	0	0	1	SIERRA NEVADA
573		243	78	504	95	426	84	18	14,679	59	41	3	38	59	248	3	1	4	0	0	0	0	0	0	1	SIERRA NEVADA
574		402	89	811	148	722	89	19	23,023	93	3	2	1	97	246	5	0	4	0	0	0	0	0	0	1	NORTH COAST
575	Capay Hills	250	61	585	113	524	95	10	75,133	304	1	1	0	99	225	8	3	5	0	0	0	0	1	0	2	GREAT CENTRAL VALLEY, NORTH COAST
576		536	161	966	160	805	95	16	63,435	257	88	59	29	12	244	12	6	6	0	0	0	45	1	0	1	NORTH COAST
577		425	165	702	125	537	70	11	2,091	8	47	29	18	53	264	5	0	0	0	0	0	0	0	0	1	SIERRA NEVADA
578		2,013	1,518	2,551	234	1,033	90	15	9,306	38	78	0	78	22	213	2	0	0	0	0	0	0	0	0	1	SIERRA NEVADA
579		95	46	216	33	170	77	17	2,410	10	0	0	0	100	246	1	0	2	0	0	0	0	0	0	1	SIERRA NEVADA
580	Big Foot Mountain	384	195	625	75	430	95	9	11,860	48	24	24	0	76	247	4	0	0	0	0	0	0	0	0	1	NORTH COAST
581		78	13	236	44	223	88	22	5,938	24	0	0	0	100	239	5	0	1	100	0	0	0	0	0	1	GREAT CENTRAL VALLEY
582		278	122	527	72	405	94	12	3,057	12	0	0	0	100	242	3	1	1	0	0	0	0	0	0	1	NORTH COAST
583		1,098	905	1,306	89	401	83	23	3,145	13	78	58	19	22	213	3	1	1	0	0	0	0	0	0	1	SIERRA NEVADA
584		504	168	883	151	715	96	5	6,482	26	8	0	8	92	242	0	1	1	0	0	0	0	0	0	1	NORTH COAST
585		300	49	846	196	797	91	22	57,037	231	10	4	6	90	224	6	5	4	0	0	0	4	1	0	2	GREAT CENTRAL VALLEY, NORTH COAST
586		119	33	280	48	247	77	18	5,953	24	0	0	0	100	252	4	1	1	0	0	0	0	0	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
587	Gube Mountain	424	139	781	135	642	95	10	14,948	60	0	0	0	100	243	2	0	1	0	0	0	0	0	0	1	NORTH COAST
588	Colusa National Wildlife Refuge	13	12	19	1	7	53	39	4,498	18	91	88	3	9	221	3	3	3	0	0	0	0	0	84	1	GREAT CENTRAL VALLEY
589		73	35	117	21	82	76	16	2,160	9	0	0	0	100	253	3	0	1	0	0	0	11	1	19	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
590	Chaparral Hill/ Yuba River	371	67	864	167	797	76	19	29,874	121	40	21	19	60	253	10	1	7	0	0	0	2	1	0	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
591		1,814	1,535	2,020	89	485	90	15	5,120	21	92	0	92	8	231	18	2	0	0	0	0	0	0	0	2	SIERRA NEVADA, MODOC PLATEAU
592		495	362	743	72	381	71	18	2,569	10	3	0	3	97	268	5	1	0	0	0	0	0	0	0	1	SIERRA NEVADA
593		216	167	290	25	123	74	16	2,034	8	0	0	0	100	253	5	0	1	0	0	0	0	0	0	1	SIERRA NEVADA
594		151	17	635	107	618	89	20	25,018	101	7	7	0	93	233	4	3	3	94	0	0	0	0	0	1	GREAT CENTRAL VALLEY
595	Lafayette Ridge/ Black Buttes	1,741	448	2,782	509	2,334	85	19	176,772	715	62	26	36	38	195	14	20	12	0	1	1	0	1	2	1	SIERRA NEVADA
596		114	45	278	50	233	73	24	4,714	19	0	0	0	100	260	4	0	1	0	0	0	0	0	3	1	SIERRA NEVADA
597		1,927	1,559	2,438	169	879	85	25	15,239	62	96	0	96	4	229	14	2	0	0	0	0	0	0	0	1	SIERRA NEVADA
598		372	191	681	99	490	78	15	9,468	38	46	28	18	54	264	7	1	1	0	0	0	0	0	0	1	SIERRA NEVADA
599		487	190	789	118	599	93	10	2,627	11	0	0	0	100	242	2	0	1	0	0	0	0	0	0	1	NORTH COAST
600	Sanel Mountain	553	168	1,015	198	847	95	10	27,402	111	0	0	0	100	242	9	3	1	0	0	0	0	0	0	1	NORTH COAST
601	Colusa Basin	17	15	22	1	7	26	37	6,078	25	96	96	0	4	218	3	0	1	0	0	0	0	0	34	1	GREAT CENTRAL VALLEY
602		1,464	845	2,117	265	1,272	80	23	15,264	62	67	0	67	33	202	2	3	4	0	0	0	0	0	0	1	SIERRA NEVADA
603		76	29	186	35	157	74	20	10,526	43	7	7	0	93	244	10	2	3	0	0	0	14	1	29	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
604		769	530	1,005	92	475	64	23	3,458	14	25	22	3	75	255	20	1	0	0	11	1	14	1	0	1	SIERRA NEVADA
605		1,634	1,517	1,858	76	341	90	24	2,686	11	100	0	100	0	222	8	3	0	0	0	0	0	0	0	1	MODOC PLATEAU
606		162	72	252	41	180	74	20	5,184	21	0	0	0	100	261	3	1	0	0	0	0	0	0	0	1	SIERRA NEVADA
607		670	325	1,340	190	1,015	96	13	69,951	283	72	14	58	28	246	13	22	12	0	0	0	0	0	0	1	NORTH COAST
608	Butte Sink	16	14	25	2	11	59	42	22,016	89	94	91	3	6	232	5	1	9	45	0	0	0	0	62	1	GREAT CENTRAL VALLEY
609		895	714	1,124	75	410	66	29	3,198	13	90	50	40	10	225	1	1	0	0	2	1	74	1	0	1	SIERRA NEVADA
610	Delevan National Wildlife Refuge	18	17	20	1	3	79	20	5,658	23	100	100	0	0	222	1	2	2	0	0	0	0	0	75	1	GREAT CENTRAL VALLEY
611		423	153	811	127	658	75	18	15,304	62	0	0	0	100	257	8	1	0	0	0	0	0	0	0	1	SIERRA NEVADA
612		308	45	732	155	687	93	19	65,560	265	5	0	5	95	223	7	14	8	0	0	0	0	0	0	2	GREAT CENTRAL VALLEY, NORTH COAST
613	Bald Mountain Range	1,871	1,469	2,662	272	1,193	89	18	57,942	234	69	17	52	31	239	14	7	2	0	0	0	0	0	0	2	SIERRA NEVADA, MODOC PLATEAU
614		1,487	1,484	1,494	1	10	89	16	2,923	12	0	0	0	100	233	8	1	2	0	0	0	0	0	87	2	SIERRA NEVADA, MODOC PLATEAU
615	Mayacmas Mountains	752	399	1,142	114	743	97	12	29,669	120	89	0	89	11	239	2	4	0	0	0	0	0	0	0	1	NORTH COAST
616	Sacramento National Wildlife Refuge	22	18	28	2	10	55	40	11,633	47	98	98	0	2	219	2	6	4	0	0	0	12	1	57	1	GREAT CENTRAL VALLEY
617		1,853	1,452	2,174	151	722	64	22	3,699	15	100	83	17	0	213	7	1	3	0	0	0	0	0	1	1	SIERRA NEVADA

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
567	6	Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Tahoe-Truckee, Glaciated Batholith and Volcanic Flows, Tahoe Valley, Batholith and Volcanic Flows	4	AMERICAN RIVER, LAKE TAHOE, TRUCKEE RIVER, YUBA RIVER	0	2	Placer, El Dorado	78	10	0	5	0	0	0	0	7
568	2	Upper Batholith and Volcanic Flows, Tahoe-Truckee	1	TRUCKEE RIVER	0	2	Nevada, Placer	83	1	0	10	1	5	0	0	0
569	2	Tahoe-Truckee, Carson Range	1	TRUCKEE RIVER	0	1	Nevada	83	3	0	2	0	0	0	0	12
570	3	Yolo Alluvial Fans, Ultramafic Complex, Western Foothills	4	CACHE CREEK, PUTAH CREEK, UPPER ELMIRA, VALLEY PUTAH-CACHE	2	3	Lake, Yolo, Napa	5	69	24	0	0	1	0	0	1
571	1	Tahoe-Truckee	2	LITTLE TRUCKEE RIVER, TRUCKEE RIVER	0	1	Nevada	91	1	0	2	0	0	0	0	6
572	2	Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows	2	AMERICAN RIVER, YUBA RIVER	0	1	Placer	89	6	0	5	0	0	0	0	1
573	1	Lower Foothills Metamorphic Belt	1	BEAR RIVER	0	2	Yuba, Nevada	0	87	6	6	0	1	0	0	0
574	1	Coastal Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	0	1	Sonoma	43	40	12	0	0	1	0	0	4
575	3	Yolo Alluvial Fans, Western Foothills, Dunnigan Hills	3	COLUSA BASIN, UPPER ELMIRA, VALLEY PUTAH-CACHE	1	2	Colusa, Yolo	0	71	27	0	0	0	1	0	0
576	3	Clear Lake Hills and Valleys, Ultramafic Complex, Western Foothills	2	CACHE CREEK, PUTAH CREEK	38	3	Lake, Colusa, Yolo	14	74	8	0	0	0	0	0	3
577	2	Granitic and Metamorphic Foothills, Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	1	Nevada	2	92	0	6	0	0	0	0	0
578	1	Tahoe-Truckee	2	LITTLE TRUCKEE RIVER, TRUCKEE RIVER	0	2	Sierra, Nevada	85	10	0	2	0	0	0	0	2
579	1	Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	1	Yuba	0	85	1	12	0	0	0	2	0
580	2	Coastal Franciscan, Central Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	0	2	Mendocino, Sonoma	34	51	11	0	0	1	0	0	3
581	2	Butte Sink-Sutter Basin, River Alluvium	1	COLUSA BASIN	0	1	Sutter	0	9	80	1	0	3	6	1	0
582	1	Central Franciscan	1	RUSSIAN RIVER	0	1	Mendocino	26	47	24	0	0	0	0	0	2
583	1	Upper Foothills Metamorphic Belt	1	YUBA RIVER	0	1	Nevada	82	11	0	7	0	0	0	0	0
584	1	Central Franciscan	1	RUSSIAN RIVER	0	1	Mendocino	14	77	7	0	0	0	0	0	1
585	3	Yolo Alluvial Fans, Western Foothills, Dunnigan Hills	5	CACHE CREEK, COLUSA BASIN, CORTINA, UPPER ELMIRA, VALLEY PUTAH-CACHE	4	2	Colusa, Yolo	1	67	30	0	0	0	1	0	0
586	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	2	MARYSVILLE, YUBA RIVER	0	1	Yuba	0	82	10	3	1	1	1	2	0
587	1	Coastal Franciscan	1	MENDOCINO COAST	0	2	Mendocino, Sonoma	47	39	12	0	0	0	0	0	3
588	2	Colusa Basin, Yolo Alluvial Fans	1	COLUSA BASIN	0	1	Colusa	0	3	49	32	1	4	11	0	0
589	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	2	MARYSVILLE, YUBA RIVER	0	1	Yuba	0	65	31	2	0	1	1	0	0
590	2	Granitic and Metamorphic Foothills, Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	2	Yuba, Nevada	19	71	0	8	1	0	0	0	1
591	2	Tahoe-Truckee, Fort Sage Mountains-Lemmon Valley	2	SUSANVILLE, TRUCKEE RIVER	0	1	Sierra	80	17	0	2	0	0	0	0	0
592	1	Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	1	Yuba	20	71	0	8	0	0	0	0	0
593	1	Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	2	Butte, Yuba	0	89	0	11	0	0	0	0	0
594	1	Butte Sink-Sutter Basin	1	COLUSA BASIN	0	1	Sutter	0	58	38	0	0	1	3	0	0
595	4	Granitic and Metamorphic Foothills, Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Tahoe-Truckee	4	BEAR RIVER, LITTLE TRUCKEE RIVER, TRUCKEE RIVER, YUBA RIVER	0	3	Sierra, Yuba, Nevada	81	10	0	5	1	0	0	0	3
596	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	1	Butte	0	38	57	5	0	0	0	0	0
597	2	Sierra Valley, Tahoe-Truckee	2	FEATHER RIVER, LITTLE TRUCKEE RIVER	0	1	Sierra	80	17	0	2	0	0	0	0	0
598	2	Granitic and Metamorphic Foothills, Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	2	Butte, Yuba	8	85	0	8	0	0	0	0	0
599	1	Coastal Franciscan	1	MENDOCINO COAST	0	1	Mendocino	60	32	6	0	0	0	0	0	2
600	1	Central Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	0	1	Mendocino	21	54	16	0	0	1	0	0	8
601	1	Colusa Basin	1	COLUSA BASIN	0	1	Colusa	0	11	8	15	4	2	60	0	0
602	2	Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows	1	YUBA RIVER	0	1	Sierra	93	1	0	6	0	0	0	0	0
603	2	River Alluvium, Hardpan Terraces	2	MARYSVILLE, YUBA RIVER	0	1	Butte	0	33	58	6	0	1	1	1	0
604	2	Granitic and Metamorphic Foothills, Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	1	Yuba	69	28	0	2	0	0	0	0	0
605	1	Fort Sage Mountains-Lemmon Valley	1	SUSANVILLE	0	2	Lassen, Sierra	14	85	0	0	0	0	0	0	0
606	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	1	YUBA RIVER	0	1	Butte	0	81	7	11	0	0	0	0	0
607	4	Eastern Franciscan, Central Franciscan, Clear Lake Hills and Valleys, Western Foothills	1	CACHE CREEK	3	2	Lake, Colusa	20	69	7	0	1	1	0	0	2
608	2	Butte Sink-Sutter Basin, River Alluvium	1	COLUSA BASIN	0	3	Butte, Colusa, Sutter	0	3	15	56	0	1	25	0	0
609	1	Granitic and Metamorphic Foothills	1	YUBA RIVER	0	1	Yuba	95	1	0	3	0	1	0	0	0
610	1	Colusa Basin	1	COLUSA BASIN	0	1	Colusa	0	6	43	48	1	1	2	0	0
611	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	2	FEATHER RIVER, YUBA RIVER	0	2	Butte, Yuba	5	86	0	9	0	0	0	0	0
612	3	Eastern Franciscan, Western Foothills, Dunnigan Hills	4	CACHE CREEK, COLUSA BASIN, CORTINA, STONY CREEK	0	1	Colusa	0	58	41	0	0	0	0	0	0
613	4	Frenchman, Sierra Valley, Tahoe-Truckee, Fort Sage Mountains-Lemmon Valley	4	FEATHER RIVER, LITTLE TRUCKEE RIVER, SUSANVILLE, TRUCKEE RIVER	0	3	Lassen, Plumas, Sierra	58	39	0	1	0	0	0	0	2
614	1	Sierra Valley	1	FEATHER RIVER	0	2	Plumas, Sierra	3	43	0	54	0	0	0	0	0
615	1	Central Franciscan	2	CACHE CREEK, RUSSIAN RIVER	0	2	Mendocino, Lake	31	67	1	0	0	1	0	0	0
616	2	North Valley Alluvium, Colusa Basin	1	COLUSA BASIN	0	2	Glenn, Colusa	0	4	31	31	0	3	30	0	0
617	2	Greenville-Graeagle, Upper Batholith and Volcanic Flows	2	FEATHER RIVER, YUBA RIVER	0	2	Plumas, Sierra	94	0	0	5	0	1	0	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
618		1,801	1,544	2,201	122	657	86	15	3,257	13	86	0	85	14	245	5	0	1	0	0	0	0	0	0	1	SIERRA NEVADA
619		1,486	1,484	1,495	2	11	92	13	3,955	16	8	8	0	92	237	12	3	3	0	0	0	0	0	42	2	SIERRA NEVADA, MODOC PLATEAU
620		304	119	412	77	293	88	9	2,447	10	3	0	3	97	255	1	2	2	0	0	0	0	0	25	1	SIERRA NEVADA
621	Sacramento National Wildlife Refuge/ Provident Main Canal	26	21	32	2	11	54	41	11,840	48	100	100	0	0	217	3	12	3	0	0	0	16	1	59	1	GREAT CENTRAL VALLEY
622		67	42	153	15	111	86	25	4,596	19	0	0	0	100	246	11	7	6	0	99	2	99	1	77	1	GREAT CENTRAL VALLEY
623		438	219	726	108	507	87	15	2,201	9	49	47	2	51	250	5	3	1	0	50	2	0	0	0	1	NORTH COAST
624	Adams Peak	1,776	1,349	2,486	241	1,137	84	18	13,240	54	73	40	33	27	264	9	3	1	0	0	0	0	0	1	2	SIERRA NEVADA, MODOC PLATEAU
625	North Table Mountain	281	83	479	102	396	85	14	12,450	50	29	28	1	71	263	5	6	5	0	2	2	3	1	34	2	SIERRA NEVADA, GREAT CENTRAL VALLEY
626		48	41	81	6	40	72	31	2,498	10	8	8	0	92	252	3	2	1	0	73	1	73	1	73	1	GREAT CENTRAL VALLEY
627		105	79	171	18	92	74	24	2,518	10	0	0	0	100	266	2	1	1	0	42	1	42	1	11	1	GREAT CENTRAL VALLEY
628		71	53	109	9	56	80	25	3,820	15	0	0	0	100	258	1	5	1	0	0	0	90	1	72	1	GREAT CENTRAL VALLEY
629	Reconnaissance Peak	1,801	1,490	2,494	223	1,004	90	16	19,489	79	82	4	78	18	249	11	6	1	0	0	0	0	0	1	2	SIERRA NEVADA, MODOC PLATEAU
630		423	226	648	82	422	90	14	4,124	17	41	37	4	59	252	6	2	1	0	15	2	0	0	0	1	NORTH COAST
631		1,786	1,415	2,038	127	623	89	18	2,133	9	80	0	80	20	231	1	1	1	0	0	0	0	0	0	1	SIERRA NEVADA
632		167	32	366	58	334	63	20	4,718	19	94	94	0	6	269	12	8	3	0	0	0	0	0	0	1	NORTH COAST
633		1,860	1,317	2,370	287	1,053	85	16	2,769	11	91	0	91	9	280	23	2	1	0	0	0	0	0	0	2	SIERRA NEVADA, MODOC PLATEAU
634		846	456	1,414	207	958	93	16	13,093	53	74	0	74	26	243	2	4	1	0	14	1	0	0	0	1	NORTH COAST
635		30	20	36	3	16	58	40	12,060	49	87	77	10	13	229	1	4	11	0	0	0	10	1	31	1	GREAT CENTRAL VALLEY
636		75	52	147	15	95	86	8	3,052	12	0	0	0	100	254	3	2	0	0	0	0	93	1	52	2	GREAT CENTRAL VALLEY, MODOC PLATEAU
637	Mt Killmore	1,635	578	2,589	345	2,011	82	22	140,739	570	86	38	48	14	205	8	15	14	0	0	0	0	1	1	1	SIERRA NEVADA
638		156	61	320	57	259	84	19	2,227	9	0	0	0	100	250	7	1	0	0	0	0	100	1	58	2	GREAT CENTRAL VALLEY, MODOC PLATEAU
639	Red Clover Valley	1,667	1,650	1,824	14	174	95	12	3,590	15	22	0	22	78	223	3	3	2	0	0	0	0	0	33	1	SIERRA NEVADA
640		128	7	200	41	193	54	32	2,068	8	92	92	0	8	274	13	10	5	0	0	0	0	0	0	1	NORTH COAST
641		1,098	265	2,130	424	1,865	85	20	149,607	605	65	27	38	35	218	20	20	8	0	0	0	20	1	0	1	SIERRA NEVADA
642	Snow Mountain	892	229	2,143	382	1,914	91	18	214,981	870	81	29	52	19	241	8	33	8	0	5	1	0	0	0	1	NORTH COAST
643	Big River/ Hi Chute Ridge	114	0	371	70	371	55	26	17,834	72	97	96	1	3	264	9	16	6	0	6	1	0	0	0	1	NORTH COAST
644	Clark Valley	229	35	623	129	588	93	16	114,249	462	2	0	2	98	222	8	12	2	0	0	0	0	0	3	2	GREAT CENTRAL VALLEY, NORTH COAST
645		906	504	1,267	160	763	86	15	2,857	12	79	0	79	21	223	3	8	2	0	0	0	100	1	0	1	MODOC PLATEAU
646		39	31	44	3	13	34	39	3,023	12	68	68	0	32	228	2	3	10	0	0	0	0	0	24	1	GREAT CENTRAL VALLEY
647	Fort Sage Mountains	1,605	1,219	2,190	263	971	98	10	15,879	64	83	2	81	17	233	12	5	1	0	0	0	0	0	0	1	MODOC PLATEAU
648		181	56	495	105	439	51	37	5,031	20	85	85	0	15	259	3	9	9	0	38	3	39	1	30	2	GREAT CENTRAL VALLEY, MODOC PLATEAU
649		1,261	1,232	1,277	10	45	97	12	3,619	15	71	1	71	29	237	4	4	2	0	0	0	0	0	0	1	MODOC PLATEAU
650		1,188	933	1,527	114	594	87	18	2,224	9	99	0	99	1	223	6	1	0	0	0	0	0	0	0	1	SIERRA NEVADA
651		618	203	1,379	302	1,176	93	19	25,005	101	62	0	62	38	243	12	4	2	0	0	0	0	0	0	1	NORTH COAST
652	Diamond Mountains	1,742	1,252	2,184	228	932	90	17	28,945	117	78	4	75	22	276	25	7	0	0	0	0	0	0	2	2	SIERRA NEVADA, MODOC PLATEAU
653		1,316	965	1,637	145	672	88	17	2,147	9	100	0	100	0	211	0	3	0	0	0	0	0	0	0	1	SIERRA NEVADA
654	Grizzly Mountain	1,765	1,078	2,350	306	1,272	85	20	20,141	82	93	31	62	7	231	3	7	3	0	0	0	0	0	1	1	SIERRA NEVADA
655	Big Bar Mountain/ Stevens Ridge	1,121	68	2,181	520	2,113	84	23	114,028	461	78	27	51	22	223	27	23	13	0	1	1	50	1	0	2	SIERRA NEVADA, MODOC PLATEAU
656		596	184	1,003	188	819	42	23	9,548	39	97	97	1	3	264	17	3	2	0	0	0	0	0	0	1	MODOC PLATEAU
657		107	80	132	10	52	84	19	3,721	15	0	0	0	100	216	2	2	1	0	93	1	93	1	98	1	GREAT CENTRAL VALLEY
658		1,389	922	1,739	153	817	90	16	3,042	12	81	0	81	19	219	4	2	2	0	0	0	0	0	1	1	SIERRA NEVADA
659		1,220	1,218	1,223	1	5	96	11	3,299	13	100	0	100	0	235	2	0	0	0	0	0	0	0	9	1	MODOC PLATEAU
660	Orland Buttes/ Stone Valley/ Julian Rocks	206	61	443	81	382	92	17	78,400	317	0	0	0	100	212	7	3	0	0	0	0	0	0	0	2	GREAT CENTRAL VALLEY, NORTH COAST
661		70	58	103	8	45	80	28	7,392	30	20	20	0	80	232	5	7	6	0	0	0	92	1	90	2	GREAT CENTRAL VALLEY, MODOC PLATEAU
662	Cottonwood Peak	1,777	1,260	2,120	178	860	86	20	10,504	43	84	0	84	16	258	30	1	0	0	0	0	0	0	2	2	SIERRA NEVADA, MODOC PLATEAU
663		57	45	68	4	23	64	39	5,924	24	41	35	5	59	226	3	7	8	0	0	0	61	1	70	1	GREAT CENTRAL VALLEY
664		79	63	93	6	30	73	10	2,685	11	0	0	0	100	219	1	0	0	0	0	0	0	0	66	1	GREAT CENTRAL VALLEY
665	Deadwood Canyon	1,259	720	1,904	218	1,184	83	25	16,024	65	92	0	92	8	212	6	9	1	0	0	0	31	1	1	2	SIERRA NEVADA, MODOC PLATEAU
666		1,622	1,085	2,251	236	1,166	88	18	25,766	104	95	1	95	5	226	3	5	1	0	0	0	0	0	1	1	SIERRA NEVADA
667	Mount Hope	1,473	448	2,161	350	1,713	84	20	63,398	257	90	66	24	10	212	7	16	8	0	0	0	52	1	1	2	SIERRA NEVADA, MODOC PLATEAU
668		79	67	98	7	31	90	20	2,351	10	70	70	0	30	229	0	4	3	0	0	0	100	1	100	1	GREAT CENTRAL VALLEY

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
618	1	Frenchman	1	FEATHER RIVER	0	1	Plumas	91	7	0	2	0	0	0	0	0
619	1	Sierra Valley	1	FEATHER RIVER	0	1	Plumas	5	64	0	31	0	0	0	0	0
620	1	Lower Foothills Metamorphic Belt	2	BUTTE CREEK, FEATHER RIVER	0	1	Butte	0	96	0	4	0	0	0	0	0
621	1	Colusa Basin	1	COLUSA BASIN	0	2	Glenn, Colusa	0	3	23	32	1	3	29	9	0
622	1	Hardpan Terraces	2	BUTTE CREEK, COLUSA BASIN	0	1	Butte	0	14	77	5	0	0	3	0	0
623	2	Coastal Franciscan, Central Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	0	1	Mendocino	70	23	7	0	0	0	0	0	0
624	3	Diamond Mountains-Crystal Peak, Frenchman, Fort Sage Mountains-Lemmon Valley	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	58	38	0	1	0	0	0	0	3
625	2	Hardpan Terraces, Lower Foothills Metamorphic Belt	3	BUTTE CREEK, COLUSA BASIN, FEATHER RIVER	0	1	Butte	2	80	7	11	0	0	0	0	0
626	3	North Valley Alluvium, Butte Sink-Sutter Basin, Tuscan Flows	1	COLUSA BASIN	0	1	Butte	0	1	73	1	0	0	25	0	0
627	2	Hardpan Terraces, Tuscan Flows	2	BUTTE CREEK, COLUSA BASIN	0	1	Butte	1	59	14	26	0	0	0	0	0
628	3	North Valley Alluvium, Hardpan Terraces, Tuscan Flows	1	COLUSA BASIN	0	1	Butte	0	47	44	8	0	0	0	0	0
629	2	Frenchman, Sierra Valley	1	FEATHER RIVER	0	1	Plumas	58	37	0	2	0	0	0	0	3
630	2	Coastal Franciscan, Central Franciscan	2	MENDOCINO COAST, RUSSIAN RIVER	0	1	Mendocino	41	38	17	0	0	1	0	0	3
631	2	Frenchman, Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	97	0	0	1	0	0	0	0	1
632	1	Coastal Franciscan	1	MENDOCINO COAST	0	1	Mendocino	90	7	0	0	0	2	0	0	0
633	3	Diamond Mountains-Crystal Peak, Frenchman, Honey Lake Basin	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	74	22	0	2	0	0	0	0	2
634	1	Central Franciscan	3	CACHE CREEK, EEL RIVER, RUSSIAN RIVER	0	2	Mendocino, Lake	62	35	1	0	0	1	0	0	1
635	3	North Valley Alluvium, Butte Sink-Sutter Basin, River Alluvium	1	COLUSA BASIN	0	2	Butte, Glenn	0	3	11	22	5	0	38	19	0
636	1	Tuscan Flows	1	COLUSA BASIN	0	1	Butte	0	33	66	0	0	0	0	0	0
637	4	Greenville-Graeagle, Granitic and Metamorphic Foothills, Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows	2	FEATHER RIVER, YUBA RIVER	0	3	Plumas, Sierra, Yuba	91	2	0	6	0	0	0	0	1
638	1	Tuscan Flows	2	BUTTE CREEK, COLUSA BASIN	0	1	Butte	0	86	6	2	0	6	0	0	0
639	1	Frenchman	1	FEATHER RIVER	0	1	Plumas	25	54	0	20	1	0	0	0	0
640	1	Coastal Franciscan	1	MENDOCINO COAST	0	1	Mendocino	92	1	1	0	0	6	0	0	0
641	6	Greenville-Graeagle, Bucks Lake, Granitic and Metamorphic Foothills, Upper Foothills Metamorphic Belt, Upper Batholith and Volcanic Flows, Lower Foothills Metamorphic Belt	2	FEATHER RIVER, YUBA RIVER	0	4	Plumas, Butte, Sierra, Yuba	82	10	0	6	1	0	0	0	1
642	4	Eastern Franciscan, Central Franciscan, Clear Lake Hills and Valleys, Western Foothills	3	CACHE CREEK, EEL RIVER, STONY CREEK	1	3	Glenn, Lake, Colusa	45	45	5	0	0	1	0	0	3
643	1	Coastal Franciscan	1	MENDOCINO COAST	0	1	Mendocino	84	6	0	1	0	6	0	0	3
644	5	North Valley Alluvium, Colusa Basin, Eastern Franciscan, Western Foothills, Dunnigan Hills	3	COLUSA BASIN, CORTINA, STONY CREEK	0	2	Glenn, Colusa	0	34	65	0	0	1	0	0	0
645	1	Granitic and Metamorphic Foothills	1	FEATHER RIVER	0	1	Butte	90	3	0	6	0	0	0	0	1
646	1	North Valley Alluvium	2	COLUSA BASIN, TEHAMA	0	2	Butte, Glenn	0	3	3	21	4	3	66	0	0
647	2	Fort Sage Mountains-Lemmon Valley, Honey Lake Basin	1	SUSANVILLE	0	1	Lassen	33	64	0	1	0	0	0	0	1
648	2	North Valley Alluvium, Tuscan Flows	4	BUTTE CREEK, COLUSA BASIN, EASTERN TEHAMA, TEHAMA	0	1	Butte	2	57	30	4	0	7	1	0	0
649	1	Honey Lake Basin	1	SUSANVILLE	0	1	Lassen	0	86	0	12	0	1	0	0	0
650	1	Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	83	11	0	6	0	0	0	0	0
651	2	Eastern Franciscan, Western Foothills	1	STONY CREEK	0	1	Glenn	30	50	17	0	0	2	0	0	2
652	3	Diamond Mountains-Crystal Peak, Frenchman, Honey Lake Basin	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	71	27	0	1	0	0	0	0	0
653	1	Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	95	1	0	3	0	0	0	0	0
654	3	Fredonyer Butte-Grizzly Peak, Frenchman, Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	96	1	0	3	0	0	0	0	0
655	4	Greenville-Graeagle, Bucks Lake, Granitic and Metamorphic Foothills, Lower Foothills Metamorphic Belt	2	FEATHER RIVER, YUBA RIVER	0	2	Plumas, Butte	78	14	0	6	1	0	0	0	1
656	3	Shignletown-Paradise, Granitic and Metamorphic Foothills, Tuscan Flows	1	BUTTE CREEK	96	1	Butte	61	31	0	7	0	0	0	0	0
657	2	North Valley Alluvium, Tehama Terraces	1	TEHAMA	0	2	Tehama, Glenn	0	7	91	0	0	1	1	0	0
658	1	Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	91	2	0	7	0	0	0	0	0
659	1	Honey Lake Basin	1	SUSANVILLE	0	1	Lassen	0	83	0	15	0	0	0	0	2
660	4	North Valley Alluvium, Western Foothills, Tehama Terraces, Dunnigan Hills	4	COLUSA BASIN, CORTINA, STONY CREEK, TEHAMA	0	2	Tehama, Glenn	0	33	64	0	0	1	1	1	0
661	1	North Valley Alluvium	1	TEHAMA	0	2	Tehama, Butte	0	2	88	1	0	2	5	2	0
662	3	Diamond Mountains-Crystal Peak, Frenchman, Honey Lake Basin	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	63	10	0	1	0	0	0	0	26
663	1	North Valley Alluvium	1	TEHAMA	0	2	Tehama, Butte	0	5	58	8	3	2	23	0	0
664	1	North Valley Alluvium	1	TEHAMA	0	1	Tehama	0	1	94	0	0	1	2	2	0
665	1	Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	87	7	0	5	0	0	0	0	0
666	4	Diamond Mountains-Crystal Peak, Fredonyer Butte-Grizzly Peak, Frenchman, Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	89	5	0	3	0	0	0	0	3
667	4	Lassen-Almanor, Greenville-Graeagle, Bucks Lake, Granitic and Metamorphic Foothills	2	BUTTE CREEK, FEATHER RIVER	0	2	Plumas, Butte	84	10	0	5	0	0	0	0	1
668	1	North Valley Alluvium	1	TEHAMA	0	1	Tehama	0	1	90	0	0	1	8	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
669		538	184	1,355	272	1,171	92	18	52,909	214	59	23	35	41	245	13	9	4	0	0	0	0	0	0	1	NORTH COAST
670		1,217	1,215	1,222	1	7	94	10	2,085	8	70	19	50	30	235	4	0	4	0	0	0	0	0	41	1	MODOC PLATEAU
671		1,424	1,085	1,887	188	802	84	22	8,187	33	72	0	72	28	230	2	1	1	0	0	0	0	0	0	1	SIERRA NEVADA
672		230	143	413	52	270	89	18	32,596	132	0	0	0	100	214	6	4	3	0	0	0	0	0	1	2	GREAT CENTRAL VALLEY, NORTH COAST
673		162	135	205	14	70	89	21	2,242	9	0	0	0	100	227	1	0	0	0	0	0	0	0	0	2	GREAT CENTRAL VALLEY, NORTH COAST
674		1,004	366	1,616	234	1,250	96	12	40,955	166	99	64	35	1	233	5	1	1	0	17	1	0	0	0	1	NORTH COAST
675		1,974	1,594	2,271	130	677	63	21	5,236	21	92	71	22	8	236	5	2	0	0	0	0	0	0	1	1	SIERRA NEVADA
676		1,355	1,243	1,556	60	313	94	17	5,711	23	87	0	87	13	251	12	0	0	0	0	0	0	0	0	1	MODOC PLATEAU
677		2,168	1,862	2,353	85	491	86	15	2,578	10	95	0	95	5	235	3	3	3	0	0	0	0	0	1	1	SIERRA NEVADA
678		112	93	144	12	51	84	19	2,577	10	16	16	0	84	222	0	5	2	0	81	1	98	1	95	1	GREAT CENTRAL VALLEY
679		961	283	2,083	345	1,800	93	16	245,124	992	68	40	28	32	234	7	13	8	0	26	1	0	0	0	1	NORTH COAST
680		1,541	1,537	1,565	3	28	89	14	2,197	9	0	0	0	100	243	5	0	1	0	0	0	0	0	95	1	SIERRA NEVADA
681	McClure Creek	159	116	227	23	111	88	21	11,017	45	0	0	0	100	219	7	0	1	0	21	1	21	1	7	2	GREAT CENTRAL VALLEY, NORTH COAST
682	Devils Parade Ground	927	528	1,387	172	859	89	15	13,046	53	83	72	11	17	259	10	4	3	0	0	0	0	0	0	1	MODOC PLATEAU
683		601	425	767	74	342	92	10	2,145	9	0	0	0	100	253	2	0	1	0	0	0	0	0	0	1	NORTH COAST
684		110	91	135	9	44	86	21	6,182	25	0	0	0	100	223	0	0	2	0	95	1	95	1	70	1	GREAT CENTRAL VALLEY
685	Butt Mountain	1,796	1,045	2,391	253	1,346	80	19	21,953	89	98	77	22	2	219	4	1	2	0	0	0	0	0	1	1	MODOC PLATEAU
686	Black Oak Mountain	773	328	1,273	224	945	76	24	12,449	50	92	88	3	8	250	4	0	7	0	62	2	0	0	0	1	NORTH COAST
687		1,426	1,289	1,600	61	311	43	27	2,534	10	88	88	1	12	264	22	3	2	0	0	0	0	0	1	2	SIERRA NEVADA, MODOC PLATEAU
688		239	155	382	39	227	94	11	29,109	118	0	0	0	100	218	9	0	0	0	0	0	13	1	2	2	GREAT CENTRAL VALLEY, NORTH COAST
689		679	429	1,212	184	783	95	10	3,344	14	0	0	0	100	231	2	0	0	0	0	0	0	0	0	1	NORTH COAST
690		150	110	208	20	98	90	15	7,416	30	0	0	0	100	220	7	0	0	0	33	1	33	1	20	2	GREAT CENTRAL VALLEY, NORTH COAST
691	Mill Creek Rim	1,174	645	1,783	255	1,138	94	12	10,182	41	79	73	6	21	251	17	1	2	0	0	0	0	0	0	1	MODOC PLATEAU
692	Mooney Island	70	60	78	3	18	32	30	3,165	13	84	83	1	16	224	3	0	9	0	0	0	0	0	35	1	GREAT CENTRAL VALLEY
693		123	101	152	10	51	89	17	3,334	13	0	0	0	100	228	1	1	0	0	92	1	92	1	48	2	GREAT CENTRAL VALLEY, NORTH COAST
694		196	158	251	16	93	94	9	2,283	9	0	0	0	100	211	0	0	0	0	0	0	0	0	0	1	NORTH COAST
695	Ishi Wilderness	474	56	1,362	263	1,306	94	16	271,981	1,101	65	52	13	35	253	11	13	16	0	1	8	10	1	15	2	GREAT CENTRAL VALLEY, MODOC PLATEAU
696		1,895	1,739	2,126	84	387	47	28	6,370	26	99	92	7	1	238	7	0	1	0	0	0	0	0	2	1	MODOC PLATEAU
697	Red Mountain	765	227	1,244	204	1,017	72	25	12,904	52	78	77	1	22	252	8	10	0	0	57	2	0	0	0	1	NORTH COAST
698		439	167	858	148	691	89	21	29,889	121	73	47	27	27	245	6	4	3	0	11	2	11	1	4	1	MODOC PLATEAU
699		735	336	1,148	156	812	90	14	4,648	19	13	8	5	87	246	3	1	0	0	19	2	0	0	0	1	NORTH COAST
700		678	451	1,063	106	612	94	9	7,150	29	14	0	14	86	260	8	0	1	0	0	0	0	0	0	1	MODOC PLATEAU
701		417	194	941	137	747	92	15	14,869	60	4	0	4	96	247	2	7	1	0	11	2	11	1	5	1	MODOC PLATEAU
702		1,717	1,712	1,735	3	23	97	11	5,225	21	99	0	99	1	238	3	3	8	0	0	0	0	0	21	1	MODOC PLATEAU
703		1,633	1,557	1,903	82	346	62	32	7,377	30	85	74	11	15	268	7	4	10	0	0	0	0	0	12	1	MODOC PLATEAU
704		1,526	1,243	2,044	145	801	97	12	164,429	665	87	1	85	13	236	14	13	6	0	0	0	59	1	2	1	MODOC PLATEAU
705		111	96	179	10	83	36	35	5,931	24	96	96	0	4	232	4	3	7	0	4	2	7	2	0	2	MODOC PLATEAU, NORTH COAST
706	Table Mountain	197	76	503	77	427	72	32	51,076	207	86	83	3	14	238	6	11	21	0	67	2	68	1	29	3	GREAT CENTRAL VALLEY, MODOC PLATEAU, NORTH COAST
707		2,189	1,666	3,169	238	1,503	78	25	38,022	154	100	96	4	0	212	7	16	14	0	0	0	0	0	3	1	MODOC PLATEAU
708		1,707	1,699	1,725	7	26	97	8	2,488	10	100	0	100	0	237	3	1	2	0	100	1	100	1	31	1	MODOC PLATEAU
709	Sinkyone	308	1	776	176	775	76	24	10,844	44	91	91	0	9	290	12	7	0	0	88	2	0	0	0	1	NORTH COAST
710	Lassen Volcanic Wilderness	2,047	1,501	2,681	163	1,180	75	20	117,885	477	100	96	4	0	212	7	25	18	0	0	0	0	0	2	1	MODOC PLATEAU
711		533	192	1,519	252	1,327	95	15	90,326	366	5	0	5	95	233	18	6	1	0	0	0	36	1	0	1	NORTH COAST
712		1,623	1,614	1,744	22	130	97	10	15,482	63	14	0	14	86	218	7	1	2	0	0	0	0	0	24	1	MODOC PLATEAU
713		1,614	1,613	1,621	1	8	95	15	7,208	29	0	0	0	100	226	7	1	1	0	0	0	0	0	22	1	MODOC PLATEAU
714	Noble Ridge/ Beegum Gorge	955	424	1,486	184	1,062	81	24	20,939	85	91	64	27	9	241	13	2	3	0	0	0	0	0	0	1	NORTH COAST
715	Island Mountain	576	79	1,399	255	1,320	94	11	109,676	444	3	1	2	97	232	5	1	5	0	1	2	0	0	0	1	NORTH COAST
716	Bald Hills	1,745	1,560	1,996	84	436	78	26	14,653	59	80	72	9	20	267	7	1	4	0	0	0	0	0	0	1	MODOC PLATEAU
717		1,085	844	1,412	102	568	91	17	2,589	10	82	0	82	18	231	1	1	1	0	26	1	0	0	0	1	NORTH COAST
718		1,809	1,697	2,096	88	399	51	25	11,188	45	98	89	9	2	236	1	2	1	0	0	0	0	0	6	1	MODOC PLATEAU
719	Bald Hills	310	152	741	92	589	94	14	92,916	376	0	0	0	100	221	11	2	1	0	0	0	33	1	0	1	NORTH COAST

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
669	2	Eastern Franciscan, Western Foothills	2	BALL MOUNTAIN, STONY CREEK	0	2	Tehama, Glenn	15	59	23	0	0	1	0	0	0
670	1	Honey Lake Basin	1	SUSANVILLE	0	1	Lassen	0	41	0	2	37	0	7	13	0
671	3	Diamond Mountains-Crystal Peak, Fredonyer Butte-Grizzly Peak, Greenville-Graeagle	1	FEATHER RIVER	0	1	Plumas	92	3	0	4	0	0	0	0	0
672	3	North Valley Alluvium, Western Foothills, Tehama Terraces	3	BALL MOUNTAIN, STONY CREEK, TEHAMA	0	2	Tehama, Glenn	0	40	59	0	0	0	0	0	0
673	2	North Valley Alluvium, Tehama Terraces	1	TEHAMA	0	1	Tehama	0	11	84	2	0	1	0	2	0
674	1	Eastern Franciscan	1	STONY CREEK	0	2	Tehama, Glenn	68	28	0	0	0	1	0	0	3
675	1	Fredonyer Butte-Grizzly Peak	1	FEATHER RIVER	0	2	Lassen, Plumas	92	0	3	3	0	0	0	0	2
676	1	Honey Lake Basin	1	SUSANVILLE	0	1	Lassen	25	72	0	1	0	0	1	0	0
677	2	Diamond Mountains-Crystal Peak, Fredonyer Butte-Grizzly Peak	2	FEATHER RIVER, SUSANVILLE	0	2	Lassen, Plumas	82	16	0	0	0	0	0	0	2
678	2	North Valley Alluvium, Tehama Terraces	1	TEHAMA	0	1	Tehama	0	5	90	1	0	3	0	1	0
679	2	Eastern Franciscan, Central Franciscan	2	EEL RIVER, STONY CREEK	0	3	Mendocino, Glenn, Lake	56	28	3	0	0	1	0	0	12
680	1	Fredonyer Butte-Grizzly Peak	1	FEATHER RIVER	0	1	Lassen	22	41	0	37	0	0	0	0	0
681	2	North Valley Alluvium, Tehama Terraces	1	TEHAMA	0	1	Tehama	0	12	87	0	0	0	0	1	0
682	2	Shignletown-Paradise, Tuscan Flows	1	EASTERN TEHAMA	0	1	Tehama	47	46	0	7	0	0	0	0	0
683	1	Coastal Franciscan	2	EEL RIVER, MENDOCINO COAST	0	1	Mendocino	96	1	0	0	0	0	0	0	2
684	2	North Valley Alluvium, Tehama Terraces	1	TEHAMA	0	1	Tehama	0	1	92	1	0	1	1	5	0
685	2	Shignletown-Paradise, Lassen-Almanor	3	BUTTE CREEK, EASTERN TEHAMA, FEATHER RIVER	0	2	Tehama, Plumas	94	0	0	4	0	0	0	0	1
686	1	Coastal Franciscan	1	EEL RIVER	60	1	Mendocino	92	7	0	0	0	0	0	0	0
687	3	Blacks Mountain-Susanville Peak, Fredonyer Butte-Grizzly Peak, Honey Lake Basin	1	SUSANVILLE	88	1	Lassen	83	10	0	6	0	0	0	0	0
688	3	North Valley Alluvium, Western Foothills, Tehama Terraces	2	BALL MOUNTAIN, TEHAMA	0	1	Tehama	0	45	54	1	0	0	0	0	0
689	1	Central Franciscan	1	EEL RIVER	0	1	Mendocino	21	46	17	0	0	3	0	0	13
690	2	North Valley Alluvium, Tehama Terraces	1	TEHAMA	0	1	Tehama	0	11	86	1	0	1	0	0	0
691	3	Shignletown-Paradise, Lassen-Almanor, Tuscan Flows	1	EASTERN TEHAMA	0	1	Tehama	61	31	0	8	0	0	0	0	0
692	1	North Valley Alluvium	1	TEHAMA	0	1	Tehama	0	8	8	25	4	1	50	4	0
693	2	North Valley Alluvium, Tehama Terraces	1	TEHAMA	0	1	Tehama	0	7	90	0	0	1	0	2	0
694	1	Tehama Terraces	1	TEHAMA	0	1	Tehama	0	24	75	1	0	0	0	0	0
695	3	North Valley Alluvium, Shignletown-Paradise, Tuscan Flows	2	EASTERN TEHAMA, TEHAMA	0	2	Tehama, Butte	5	76	14	3	0	0	0	0	0
696	2	Blacks Mountain-Susanville Peak, Lassen-Almanor	1	FEATHER RIVER	0	2	Lassen, Plumas	45	0	0	3	0	0	0	0	52
697	2	Coastal Franciscan, Central Franciscan	1	EEL RIVER	52	1	Mendocino	61	6	0	0	0	2	0	0	31
698	1	Tuscan Flows	3	EASTERN TEHAMA, REDDING, TEHAMA	1	1	Tehama	0	93	5	1	0	0	0	0	0
699	2	Coastal Franciscan, Central Franciscan	1	EEL RIVER	0	1	Mendocino	51	21	6	0	0	1	0	0	22
700	2	Shignletown-Paradise, Tuscan Flows	1	WHITMORE	0	1	Tehama	13	83	0	4	0	0	0	0	0
701	1	Tuscan Flows	3	EASTERN TEHAMA, REDDING, WHITMORE	0	1	Tehama	28	67	2	2	0	0	0	1	0
702	1	Blacks Mountain-Susanville Peak	1	SUSANVILLE	0	1	Lassen	10	67	0	23	0	0	0	0	0
703	2	Blacks Mountain-Susanville Peak, Eagle Lake-Observation Peak	1	SUSANVILLE	54	1	Lassen	63	15	0	2	12	0	2	0	5
704	4	Eagle Lake-Observation Peak, Honey Lake Basin, Cottonwood-Skedaddle Mountains, Madeline Plain	2	MADELINE PLAINS, SUSANVILLE	1	1	Lassen	13	84	0	2	0	0	0	0	1
705	2	Tehama Terraces, Tuscan Flows	1	REDDING	95	2	Shasta, Tehama	0	23	15	10	9	4	29	9	0
706	3	North Valley Alluvium, Tehama Terraces, Tuscan Flows	3	REDDING, TEHAMA, WHITMORE	65	2	Shasta, Tehama	0	55	36	2	2	2	1	2	0
707	1	Lassen-Almanor	4	EASTERN TEHAMA, FEATHER RIVER, PIT RIVER, WHITMORE	0	2	Shasta, Tehama	77	4	0	3	0	0	0	0	15
708	2	Blacks Mountain-Susanville Peak, Lassen-Almanor	1	PIT RIVER	0	1	Lassen	27	61	0	12	0	0	0	0	0
709	1	Coastal Franciscan	3	CAPE MENDOCINO, EEL RIVER, MENDOCINO COAST	0	2	Humboldt, Mendocino	85	8	1	0	1	2	0	0	3
710	3	Blacks Mountain-Susanville Peak, Hat Creek Rim, Lassen-Almanor	5	EASTERN TEHAMA, FEATHER RIVER, PIT RIVER, SUSANVILLE, WHITMORE	0	4	Shasta, Lassen, Tehama, Plumas	89	0	0	5	2	0	0	0	5
711	5	Trinity Mountain-Hayfork, Rattlesnake Creek, Eastern Franciscan, Western Foothills, Tehama Terraces	3	REDDING, SHASTA BALLY, TEHAMA	0	1	Tehama	10	80	8	1	0	1	0	0	0
712	2	Likely Mountain, Madeline Plain	1	MADELINE PLAINS	0	1	Lassen	1	98	0	1	0	0	0	0	0
713	1	Madeline Plain	1	MADELINE PLAINS	0	1	Lassen	0	98	0	1	0	0	0	0	0
714	3	Trinity Mountain-Hayfork, Rattlesnake Creek, Western Foothills	1	SHASTA BALLY	0	2	Shasta, Tehama	55	43	0	0	0	1	0	0	1
715	2	Coastal Franciscan, Central Franciscan	1	EEL RIVER	0	3	Humboldt, Trinity, Mendocino	38	30	9	0	1	1	0	0	22
716	2	Blacks Mountain-Susanville Peak, Eagle Lake-Observation Peak	2	MADELINE PLAINS, SUSANVILLE	71	1	Lassen	88	11	0	1	0	0	0	0	0
717	2	Trinity Mountain-Hayfork, Rattlesnake Creek	2	SHASTA BALLY, TRINITY RIVER	0	2	Trinity, Shasta	90	10	0	0	0	0	0	0	0
718	1	Blacks Mountain-Susanville Peak	2	PIT RIVER, SUSANVILLE	0	1	Lassen	63	8	0	6	0	0	0	0	23
719	3	Trinity Mountain-Hayfork, Western Foothills, Tehama Terraces	2	REDDING, SHASTA BALLY	0	2	Shasta, Tehama	0	69	29	1	0	0	0	0	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
720		1,087	164	2,458	515	2,294	90	18	469,746	1,901	68	53	16	32	231	11	29	14	0	6	1	19	1	0	2	GREAT CENTRAL VALLEY, NORTH COAST
721		1,749	1,485	2,418	137	933	93	19	141,598	573	70	11	59	30	239	10	8	7	0	0	0	50	1	10	1	MODOC PLATEAU
722	Thousand Lakes	1,966	1,510	2,638	185	1,128	83	15	24,063	97	100	95	4	0	224	6	3	0	0	0	0	0	0	0	1	MODOC PLATEAU
723		276	227	335	22	108	91	8	2,454	10	65	65	0	35	248	7	0	0	0	0	0	0	0	98	1	MODOC PLATEAU
724	South Fork Mountain/ Chinquapin Butte	1,135	713	1,834	238	1,121	90	18	38,060	154	94	62	32	6	231	3	6	4	0	58	1	0	0	0	1	NORTH COAST
725	Yellow Jacket Butte	330	43	770	182	727	93	10	10,557	43	1	0	1	99	235	4	1	1	0	1	1	0	0	0	1	NORTH COAST
726		239	58	579	101	521	48	31	2,618	11	99	99	0	1	239	1	0	1	0	97	1	0	0	0	1	NORTH COAST
727		1,803	1,486	2,075	147	589	69	24	2,380	10	88	87	2	12	228	1	0	0	0	0	0	0	0	2	1	MODOC PLATEAU
728		1,849	1,380	2,355	216	975	95	9	2,983	12	97	0	97	3	242	7	1	2	0	0	0	0	0	0	1	MODOC PLATEAU
729		333	66	831	174	765	93	9	3,608	15	0	0	0	100	250	1	0	1	0	0	0	0	0	0	1	NORTH COAST
730	Humboldt Redwoods/ Grasshopper Mountain	426	32	1,029	212	997	75	27	31,685	128	98	98	0	2	240	3	5	5	0	98	1	0	0	0	1	NORTH COAST
731	Charles Mountain	1,042	248	1,784	286	1,536	92	13	37,937	154	38	21	18	62	236	4	6	4	0	37	2	0	0	0	1	NORTH COAST
732		1,021	367	1,941	291	1,574	88	19	62,886	254	64	38	26	36	236	7	2	6	0	8	1	0	0	0	1	NORTH COAST
733	King Range	496	3	1,216	236	1,213	80	20	36,467	148	99	98	0	1	269	21	2	6	0	44	2	0	0	0	1	NORTH COAST
734	Whiskeytown	809	257	1,881	384	1,624	64	26	34,575	140	94	93	1	6	248	6	3	13	0	0	0	0	0	0	1	NORTH COAST
735		517	351	983	103	632	73	35	5,758	23	91	87	4	9	254	1	2	6	0	0	0	0	0	0	1	NORTH COAST
736	Cinder Butte	1,120	973	1,563	107	590	93	17	35,742	145	94	66	28	6	236	7	4	6	0	4	2	4	1	0	1	MODOC PLATEAU
737		430	261	835	102	574	89	24	4,920	20	61	43	18	39	264	7	0	5	0	0	0	0	0	0	1	MODOC PLATEAU
738		1,369	1,362	1,386	5	24	92	16	3,576	14	3	0	3	97	222	4	2	2	0	0	0	0	0	69	1	MODOC PLATEAU
739		1,674	1,538	2,148	96	610	94	17	89,836	364	31	1	30	69	237	12	10	2	0	0	0	33	1	32	1	MODOC PLATEAU
740	Rockefeller Redwood Forest	449	44	937	199	893	72	28	14,605	59	82	82	0	18	240	3	8	5	0	79	1	0	0	0	1	NORTH COAST
741		732	394	1,092	144	698	90	24	2,256	9	57	16	41	43	254	2	0	1	0	0	0	0	0	0	1	NORTH COAST
742	Beaver Creek Rim/ Indian Mountain	1,468	1,008	1,993	217	985	96	12	92,705	375	74	4	71	26	256	8	5	4	0	0	0	0	0	2	1	MODOC PLATEAU
743		1,268	1,030	1,663	146	633	95	8	3,749	15	0	0	0	100	237	7	0	2	0	0	0	0	0	1	1	MODOC PLATEAU
744	Bear Wallow Mountain	914	447	1,557	237	1,110	92	15	20,707	84	82	63	19	18	229	3	4	6	0	17	1	0	0	0	1	NORTH COAST
745		1,070	903	1,329	58	426	96	12	8,066	33	84	0	84	16	246	8	0	4	0	0	0	0	0	1	1	MODOC PLATEAU
746	Popcorn Cave	1,134	999	1,688	107	689	97	11	17,890	72	91	0	91	9	264	10	2	1	0	0	0	0	0	1	1	MODOC PLATEAU
747		1,263	717	1,761	271	1,044	95	10	2,184	9	70	0	70	30	233	0	0	2	0	61	1	0	0	0	1	NORTH COAST
748		772	565	877	72	312	93	10	2,220	9	0	0	0	100	248	2	2	1	0	0	0	0	0	0	1	MODOC PLATEAU
749		1,081	937	1,368	93	431	96	11	3,966	16	74	0	74	26	239	1	4	0	0	26	2	16	1	2	1	MODOC PLATEAU
750		1,392	1,362	1,609	47	247	99	4	5,926	24	77	0	77	23	222	4	3	2	0	0	0	15	1	3	1	MODOC PLATEAU
751		1,382	1,273	1,549	56	276	97	10	4,984	20	92	0	92	8	260	2	0	1	0	0	0	0	0	1	1	MODOC PLATEAU
752		1,253	1,249	1,256	2	7	95	5	3,833	16	10	10	1	90	249	5	0	1	0	0	0	0	0	71	1	MODOC PLATEAU
753		491	324	808	108	484	76	32	7,097	29	100	100	0	0	257	1	2	4	0	0	0	0	0	0	1	MODOC PLATEAU
754		1,047	653	1,552	179	899	89	15	9,750	39	58	0	58	42	241	6	3	10	0	57	1	0	0	0	1	MODOC PLATEAU
755		690	277	1,046	156	769	86	20	7,183	29	0	0	0	100	241	2	3	0	0	0	0	0	0	0	1	NORTH COAST
756		905	788	1,003	38	215	94	7	2,715	11	0	0	0	100	235	5	2	0	0	0	0	0	0	2	1	MODOC PLATEAU
757		1,439	1,298	1,741	77	443	94	9	8,115	33	23	0	23	77	262	2	0	0	0	0	0	0	0	0	1	MODOC PLATEAU
758		968	853	1,027	40	174	97	8	2,128	9	99	0	99	1	244	1	2	1	0	0	0	0	0	0	1	MODOC PLATEAU
759		830	585	1,102	116	517	67	28	5,404	22	95	81	14	5	252	1	1	1	0	44	1	0	0	0	1	NORTH COAST
760		553	301	1,318	192	1,017	96	15	79,823	323	88	79	9	12	264	6	5	17	0	0	0	0	0	0	1	MODOC PLATEAU
761		1,415	1,354	1,461	25	107	97	11	2,348	10	98	0	98	2	242	5	0	2	3	0	0	0	0	0	1	MODOC PLATEAU
762		437	154	842	178	688	65	25	2,770	11	95	95	0	5	238	2	1	3	0	79	1	0	0	0	1	NORTH COAST
763		685	400	1,033	142	633	95	11	2,049	8	92	1	91	8	232	2	0	1	0	0	0	0	0	0	1	NORTH COAST
764		1,001	370	1,892	280	1,522	85	21	50,402	204	96	71	26	4	231	1	3	12	0	26	1	0	0	0	1	NORTH COAST
765	Big Valley	1,259	1,255	1,275	3	20	93	14	7,075	29	26	20	7	74	248	3	1	1	0	0	0	0	0	45	1	MODOC PLATEAU
766		544	325	1,116	175	791	89	27	3,554	14	88	23	65	12	254	1	0	1	0	0	0	0	0	0	1	NORTH COAST
767		839	722	986	54	264	68	30	2,407	10	96	90	6	4	249	1	1	1	0	95	1	0	0	0	1	NORTH COAST
768	Pilot Butte	1,266	1,258	1,304	6	46	92	20	14,259	58	87	2	86	13	250	5	7	4	0	0	0	0	0	50	1	MODOC PLATEAU
769		430	323	795	96	472	83	33	5,244	21	79	62	17	21	256	1	2	3	0	0	0	0	0	0	2	MODOC PLATEAU, NORTH COAST
770		1,423	1,306	1,608	64	302	97	10	2,859	12	29	0	29	71	263	1	0	0	0	0	0	0	0	2	1	MODOC PLATEAU
771		1,364	1,295	1,707	69	412	95	14	2,325	9	59	0	59	41	263	1	0	2	0	0	0	0	0	1	1	MODOC PLATEAU
772		830	303	1,581	276	1,278	80	23	13,461	54	89	76	13	11	236	2	2	5	0	42	1	0	0	0	1	NORTH COAST
773		1,377	1,265	1,831	110	566	96	10	13,940	56	37	0	37	63	260	3	0	3	0	0	0	0	0	0	1	MODOC PLATEAU

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
720	5	Rattlesnake Creek, Eastern Franciscan, Central Franciscan, Western Foothills, Tehama Terraces	8	BALL MOUNTAIN, EEL RIVER, MAD RIVER, REDDING, SHASTA BALLY, STONY CREEK, TEHAMA, TRINITY RIVER	0	3	Trinity, Tehama, Mendocino	64	29	4	0	0	1	0	0	2
721	3	Adin Mountains and Valleys, Eagle Lake-Observation Peak, Madeline Plain	2	MADELINE PLAINS, SUSANVILLE	11	1	Lassen	50	43	0	1	0	0	1	1	5
722	2	Hat Creek Rim, Lassen-Almanor	1	PIT RIVER	0	1	Shasta	82	0	0	3	0	0	0	0	14
723	2	Tehama Terraces, Tuscan Flows	2	REDDING, WHITMORE	0	1	Shasta	1	4	40	2	0	0	0	54	0
724	3	Rattlesnake Creek, Eastern Franciscan, Central Franciscan	3	EEL RIVER, MAD RIVER, TRINITY RIVER	0	1	Trinity	92	4	0	0	0	1	0	0	3
725	2	Central Franciscan, Central Franciscan	1	EEL RIVER	0	1	Humboldt	44	21	11	0	2	0	0	0	21
726	1	Coastal Franciscan	1	EEL RIVER	0	1	Humboldt	95	0	0	0	0	5	0	0	0
727	1	Shignletown-Paradise	2	PIT RIVER, WHITMORE	0	1	Shasta	73	1	22	5	0	0	0	0	0
728	2	Hat Creek Rim, Lassen-Almanor	1	PIT RIVER	0	1	Shasta	39	1	0	0	0	0	0	0	60
729	1	Coastal Franciscan	1	CAPE MENDOCINO	0	1	Humboldt	43	19	28	0	0	0	0	0	9
730	1	Coastal Franciscan	2	CAPE MENDOCINO, EEL RIVER	0	1	Humboldt	95	1	0	0	0	2	0	0	1
731	2	Central Franciscan, Central Franciscan	1	EEL RIVER	3	2	Humboldt, Trinity	79	6	2	0	0	0	0	0	13
732	4	Oregon Mountain, Trinity Mountain-Hayfork, Rattlesnake Creek, Western Foothills	2	SHASTA BALLY, TRINITY RIVER	0	2	Trinity, Shasta	71	26	1	0	0	1	0	0	1
733	1	Coastal Franciscan	1	CAPE MENDOCINO	2	1	Humboldt	85	11	2	0	0	1	0	0	2
734	2	Oregon Mountain, Eastern Klamath Mountains	2	SHASTA BALLY, TRINITY RIVER	0	2	Trinity, Shasta	66	28	0	1	1	3	0	0	0
735	2	Oregon Mountain, Eastern Klamath Mountains	1	SHASTA BALLY	0	1	Shasta	19	76	0	1	1	3	0	0	0
736	1	Hat Creek Rim	1	PIT RIVER	0	1	Shasta	58	12	0	1	0	0	1	0	28
737	1	Eastern Klamath Mountains	2	MOUNTAIN GATE, SHASTA DAM	0	1	Shasta	64	26	0	3	5	2	0	0	1
738	2	Cottonwood-Skedaddle Mountains, Surprise Valley	1	SUPRISE VALLEY	0	2	Modoc, Lassen	0	19	2	33	1	0	21	23	1
739	4	Likely Mountain, Adin Mountains and Valleys, Eagle Lake-Observation Peak, Madeline Plain	2	MADELINE PLAINS, PIT RIVER	1	1	Lassen	19	72	4	2	0	0	1	2	0
740	1	Coastal Franciscan	2	CAPE MENDOCINO, EEL RIVER	0	1	Humboldt	93	2	2	0	0	2	0	0	0
741	1	Eastern Klamath Mountains	1	SHASTA BALLY	0	1	Shasta	37	58	1	3	0	1	0	0	0
742	5	Blacks Mountain-Susanville Peak, Hat Creek Rim, Bald Mountain-Dixie Valley, Eagle Lake-Observation Peak, Madeline Plain	2	MADELINE PLAINS, PIT RIVER	0	2	Shasta, Lassen	32	64	0	3	0	0	0	0	0
743	2	Hat Creek Rim, Shignletown-Paradise	1	PIT RIVER	0	1	Shasta	44	1	0	1	0	0	0	0	54
744	2	Rattlesnake Creek, Eastern Franciscan	1	TRINITY RIVER	0	1	Trinity	92	5	0	0	1	0	0	0	2
745	1	Hat Creek Rim	1	PIT RIVER	0	1	Shasta	65	35	0	0	0	0	0	0	1
746	2	Hat Creek Rim, Bald Mountain-Dixie Valley	1	PIT RIVER	0	2	Shasta, Lassen	61	38	0	1	0	0	0	0	0
747	1	Trinity Mountain-Hayfork	1	TRINITY RIVER	0	1	Trinity	97	2	0	0	0	0	0	0	0
748	2	Eastern Klamath Mountains, Shignletown-Paradise	1	PIT RIVER	0	1	Shasta	87	2	0	10	0	0	0	0	0
749	1	Hat Creek Rim	1	PIT RIVER	0	1	Shasta	89	8	0	0	0	0	1	0	1
750	1	Surprise Valley	1	SUPRISE VALLEY	0	1	Modoc	0	60	0	36	0	0	0	1	3
751	2	Mowitz Buttes, Bald Mountain-Dixie Valley	1	PIT RIVER	0	1	Lassen	30	64	0	6	0	0	0	0	0
752	1	Mowitz Buttes	1	PIT RIVER	0	1	Lassen	0	2	0	14	0	0	47	36	0
753	1	Eastern Klamath Mountains	1	SHASTA DAM	0	1	Shasta	92	3	0	2	3	1	0	0	0
754	2	Hat Creek Rim, Shignletown-Paradise	1	PIT RIVER	0	1	Shasta	86	1	0	4	0	0	0	0	9
755	2	Central Franciscan, Coastal Franciscan	1	EEL RIVER	0	1	Humboldt	48	10	3	0	0	1	0	0	38
756	1	Shignletown-Paradise	1	PIT RIVER	0	1	Shasta	92	2	0	5	0	0	0	0	2
757	2	Mowitz Buttes, Adin Mountains and Valleys	1	PIT RIVER	0	2	Modoc, Lassen	10	85	1	3	0	0	0	1	0
758	1	Hat Creek Rim	1	PIT RIVER	0	1	Shasta	60	40	0	0	0	0	0	0	0
759	1	Eastern Klamath Mountains	1	TRINITY RIVER	0	1	Trinity	76	19	1	0	0	3	0	0	1
760	2	Eastern Klamath Mountains, Tehama Terraces	4	MC CLOUD RIVER, MOUNTAIN GATE, SHASTA DAM, WHITMORE	0	1	Shasta	81	9	0	2	8	0	0	0	0
761	2	Pit River Valley, Likely Mountain	1	PIT RIVER	0	1	Modoc	0	94	0	6	0	0	0	0	0
762	1	Coastal Franciscan	1	EEL RIVER	0	1	Humboldt	92	5	1	0	0	0	0	0	1
763	1	Rattlesnake Creek	1	TRINITY RIVER	0	1	Trinity	89	11	0	0	0	0	0	0	0
764	3	Oregon Mountain, Trinity Mountain-Hayfork, Rattlesnake Creek	1	TRINITY RIVER	0	1	Trinity	92	5	0	0	0	1	0	0	1
765	2	Mowitz Buttes, Bald Mountain-Dixie Valley	1	PIT RIVER	0	2	Modoc, Lassen	0	18	1	16	0	0	40	25	0
766	1	Eastern Klamath Mountains	2	SHASTA DAM, UPPER SACRAMENTO	0	1	Shasta	90	3	0	2	1	2	0	2	0
767	1	Eastern Klamath Mountains	1	TRINITY RIVER	0	1	Trinity	88	5	0	0	1	5	0	0	2
768	2	Mowitz Buttes, Adin Mountains and Valleys	1	PIT RIVER	0	2	Modoc, Lassen	0	18	2	13	1	1	17	48	0
769	1	Eastern Klamath Mountains	1	SHASTA DAM	0	1	Shasta	78	2	0	4	9	2	0	4	2
770	1	Adin Mountains and Valleys	1	PIT RIVER	0	1	Modoc	2	91	3	4	0	0	0	0	0
771	1	Adin Mountains and Valleys	1	PIT RIVER	0	1	Modoc	16	67	8	4	0	0	6	0	0
772	1	Trinity Mountain-Hayfork	1	TRINITY RIVER	0	1	Trinity	95	3	0	0	1	1	0	0	0
773	2	Mowitz Buttes, Adin Mountains and Valleys	1	PIT RIVER	0	1	Modoc	9	75	0	3	0	0	1	12	0

Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
774	Little Hot Spring Valley	1,065	1,007	1,208	33	201	89	23	32,853	133	90	85	4	10	254	10	8	12	0	11	1	11	1	4	1	MODOC PLATEAU
775		907	721	1,276	125	555	69	30	14,923	60	98	97	1	2	247	2	5	3	0	38	1	0	0	0	1	NORTH COAST
776		1,283	1,262	1,403	20	141	94	13	5,046	20	36	1	35	64	259	7	2	1	0	0	0	0	0	11	1	MODOC PLATEAU
777		1,367	1,362	1,397	6	35	99	3	32,922	133	56	0	56	44	220	2	4	1	0	0	0	3	1	1	1	MODOC PLATEAU
778		1,722	1,428	1,975	127	547	97	10	2,345	9	59	0	59	41	263	2	1	0	0	0	0	0	0	0	1	MODOC PLATEAU
779		1,673	1,335	2,244	173	909	95	15	105,515	427	74	18	56	26	249	12	18	8	0	0	0	0	0	1	1	MODOC PLATEAU
780		1,385	1,314	1,584	79	270	95	10	3,027	12	81	0	81	19	275	7	0	1	0	0	0	0	0	0	1	MODOC PLATEAU
781		1,375	1,266	1,745	95	479	96	10	4,533	18	44	0	44	56	263	4	0	1	0	0	0	0	0	2	1	MODOC PLATEAU
782		823	479	1,223	168	744	94	7	3,539	14	2	0	2	98	250	2	3	3	0	0	0	0	0	0	1	NORTH COAST
783	Dairy Ridge/ Pilot Ridge/ South Fork	944	184	1,785	303	1,601	91	15	97,579	395	46	23	24	54	237	5	11	18	0	9	2	0	0	0	1	NORTH COAST
784		897	577	1,482	151	905	83	24	32,878	133	96	84	12	4	248	4	3	2	0	52	1	0	0	0	1	NORTH COAST
785	McCloud River/ Curl Ridge	921	325	1,891	292	1,566	94	14	167,356	677	74	46	28	26	246	6	10	14	0	38	1	0	0	0	1	MODOC PLATEAU
786	Warner Mountains	1,760	1,226	3,004	263	1,778	94	17	789,959	3,197	83	14	69	17	232	15	71	23	1	0	0	33	1	3	1	MODOC PLATEAU
787		875	722	1,146	93	424	46	33	2,015	8	93	88	5	7	243	2	3	0	0	25	1	0	0	0	1	NORTH COAST
788		1,463	1,280	1,846	117	566	80	22	8,943	36	91	73	19	9	258	2	1	3	0	0	0	0	0	1	1	MODOC PLATEAU
789		1,356	613	2,182	404	1,569	95	11	5,528	22	58	10	48	42	234	5	1	7	0	9	1	0	0	1	1	NORTH COAST
790	Timbered Crater	1,139	1,030	1,214	34	184	95	14	28,071	114	96	78	18	4	246	9	0	0	0	0	1	0	1	0	1	MODOC PLATEAU
791		824	140	1,518	270	1,378	93	14	10,170	41	83	0	83	17	238	5	4	11	0	80	2	0	0	0	1	NORTH COAST
792	Backbone Ridge	909	178	2,122	392	1,944	90	21	128,079	518	84	56	28	16	246	10	12	14	0	13	1	0	0	0	2	MODOC PLATEAU, NORTH COAST
793		1,437	1,293	1,591	63	298	88	17	2,162	9	75	0	75	25	240	4	0	2	0	100	1	0	0	0	1	MODOC PLATEAU
794		1,293	1,168	1,403	49	235	97	11	5,640	23	100	0	100	0	257	8	0	0	0	0	0	0	0	0	1	MODOC PLATEAU
795	Castle Crags	1,462	623	2,186	374	1,563	84	22	19,477	79	89	77	12	11	237	7	12	9	0	13	1	0	0	0	2	MODOC PLATEAU, NORTH COAST
796		1,593	1,431	1,875	95	444	96	10	9,595	39	100	86	14	0	242	6	1	0	0	0	0	0	0	0	1	MODOC PLATEAU
797	Bald Mountain/ Lake City Canyon	1,797	1,376	2,516	246	1,140	90	18	40,763	165	74	40	35	26	271	18	17	8	0	0	0	0	0	2	1	MODOC PLATEAU
798		1,738	1,378	2,168	167	790	94	10	2,036	8	47	0	47	53	225	4	0	4	0	0	0	0	0	0	1	MODOC PLATEAU
799	Mt Eddy	2,189	1,492	2,747	198	1,255	90	18	14,149	57	73	50	23	27	231	17	16	3	0	0	0	0	0	2	1	NORTH COAST
800		1,886	1,517	2,541	222	1,024	94	9	2,657	11	47	0	47	53	222	2	0	1	0	0	0	0	0	0	1	MODOC PLATEAU
801		597	158	1,249	228	1,091	81	24	16,662	67	43	43	0	57	244	5	2	5	0	32	2	0	0	0	1	NORTH COAST
802	Timber Mountain	1,343	1,280	1,479	36	199	88	23	31,996	129	100	77	23	0	256	9	1	1	0	0	0	0	0	0	1	MODOC PLATEAU
803		1,435	1,433	1,460	2	27	95	12	5,176	21	0	0	0	100	268	12	0	7	0	0	0	0	0	58	1	MODOC PLATEAU
804		1,295	1,286	1,316	3	30	98	10	2,010	8	100	0	100	0	247	2	0	0	0	0	0	0	0	0	1	MODOC PLATEAU
805		2,109	1,491	2,406	152	915	76	23	11,733	47	98	88	11	2	235	6	2	3	0	0	0	0	0	0	1	MODOC PLATEAU
806		2,196	1,518	2,581	165	1,063	97	7	7,757	31	82	8	74	18	224	2	8	3	0	38	1	0	0	1	1	NORTH COAST
807		870	423	1,472	238	1,049	92	17	4,766	19	69	2	67	31	225	1	1	2	0	3	1	0	0	0	1	NORTH COAST
808	Mt Shasta	2,178	1,053	4,300	626	3,247	78	25	64,060	259	94	88	6	6	233	17	14	6	0	12	1	0	0	0	1	MODOC PLATEAU
809		538	72	953	241	881	92	10	2,381	10	1	0	1	99	232	2	2	1	0	0	0	0	0	0	1	NORTH COAST
810		1,469	1,316	1,614	76	298	87	23	3,445	14	99	78	21	1	258	2	3	2	0	0	0	0	0	0	1	MODOC PLATEAU
811	Big Cliff Mine	1,561	506	2,475	452	1,969	86	20	58,366	236	96	70	26	4	219	5	9	8	0	46	1	0	0	1	1	NORTH COAST
812		1,521	1,351	1,641	38	290	98	10	177,564	719	88	0	88	12	257	5	12	12	0	0	0	0	0	7	1	MODOC PLATEAU
813	Mount Bidwell/ Larkspur Hills	1,667	1,355	2,527	276	1,172	95	14	95,703	387	74	20	55	26	234	21	11	14	0	0	0	39	1	2	1	MODOC PLATEAU
814	Double Head Mountain/ Timbered Ridge	1,465	1,268	1,746	71	478	95	16	227,384	920	92	0	92	8	256	7	7	11	0	0	0	1	1	6	1	MODOC PLATEAU
815	Salmon Mountains	1,368	76	2,706	471	2,630	88	18	732,472	2,964	98	90	8	2	227	8	44	28	0	13	2	0	0	0	1	NORTH COAST
816		11	0	124	21	124	40	36	3,269	13	97	97	0	3	291	8	12	6	0	85	3	0	0	11	1	NORTH COAST
817	Lava Beds Wilderness	1,287	1,229	1,527	33	298	93	19	54,198	219	99	95	3	1	252	8	4	5	0	0	0	0	0	0	1	MODOC PLATEAU
818	McConaughy Gulch	1,123	842	1,786	189	944	90	16	22,078	89	6	0	6	94	228	5	3	1	0	0	0	0	0	0	1	NORTH COAST
819		1,293	1,231	1,602	54	371	98	11	17,918	73	100	100	0	0	253	8	1	1	0	0	0	0	0	0	1	MODOC PLATEAU
820	Redwood Creek/ Bald Hills	386	3	976	204	973	68	31	51,392	208	96	96	0	4	246	13	8	10	0	1	1	0	0	0	1	NORTH COAST
821		1,232	1,226	1,248	3	22	13	30	7,684	31	100	100	0	0	259	5	1	6	0	0	0	0	0	1	1	MODOC PLATEAU
822		815	794	936	14	142	86	27	3,005	12	0	0	0	100	261	2	1	1	0	0	0	0	0	43	1	MODOC PLATEAU

Characteristics of Natural Landscape Blocks

ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
774	3	Medicine Lake Lava Flows, Hat Creek Rim, Bald Mountain-Dixie Valley	1	PIT RIVER	0	3	Siskiyou, Modoc, Shasta	75	2	0	0	2	0	2	2	17
775	1	Eastern Klamath Mountains	1	TRINITY RIVER	0	1	Trinity	80	8	1	0	4	4	0	0	3
776	1	Mowitz Buttes	1	PIT RIVER	0	1	Modoc	17	66	0	1	0	0	0	15	0
777	1	Surprise Valley	1	SUPRISE VALLEY	0	1	Modoc	0	46	0	11	0	0	0	0	42
778	2	Likely Mountain, Adin Mountains and Valleys	1	PIT RIVER	0	1	Modoc	49	49	1	1	0	0	0	0	0
779	4	Pit River Valley, Likely Mountain, Adin Mountains and Valleys, Madeline Plain	2	MADELINE PLAINS, PIT RIVER	0	2	Modoc, Lassen	41	53	1	2	0	0	0	1	1
780	2	Pit River Valley, Likely Mountain	1	PIT RIVER	0	1	Modoc	33	43	15	3	0	0	0	0	6
781	2	Mowitz Buttes, Adin Mountains and Valleys	1	PIT RIVER	0	1	Modoc	27	66	2	5	0	0	0	0	0
782	2	Central Franciscan, Central Franciscan	1	REDWOOD CREEK	0	1	Humboldt	90	7	0	0	0	0	0	0	3
783	6	Central Franciscan, Coastal Franciscan, Western Jurassic, Rattlesnake Creek, Eastern Franciscan, Central Franciscan	4	EEL RIVER, MAD RIVER, REDWOOD CREEK, TRINITY RIVER	0	2	Humboldt, Trinity	77	9	1	0	0	1	0	0	12
784	1	Eastern Klamath Mountains	2	SHASTA BALLY, TRINITY RIVER	0	2	Trinity, Shasta	76	13	0	1	5	2	0	0	3
785	2	Eastern Klamath Mountains, Hat Creek Rim	4	MC CLOUD RIVER, PIT RIVER, SHASTA DAM, UPPER SACRAMENTO	0	2	Siskiyou, Shasta	96	1	0	2	0	0	0	0	1
786	8	Warner Mountains, Pit River Valley, Likely Mountain, Eagle Lake-Observation Peak, Honey Lake Basin, Cottonwood-Skedaddle Mountains, Madeline Plain, Surprise Valley	6	DUCK FLAT, MADELINE PLAINS, PIT RIVER, SMOKE CREEK, SUPRISE VALLEY, SUSANVILLE	0	2	Modoc, Lassen	27	64	3	2	0	0	0	1	3
787	2	Eastern Klamath Mountains, Upper Scott Mountains	1	TRINITY RIVER	0	1	Trinity	88	4	2	0	0	6	0	0	0
788	1	Adin Mountains and Valleys	1	PIT RIVER	0	1	Modoc	63	33	1	4	0	0	0	0	0
789	2	Eastern Klamath Mountains, Upper Scott Mountains	2	TRINITY RIVER, UPPER SACRAMENTO	0	2	Trinity, Shasta	92	4	0	3	0	0	0	0	0
790	2	Medicine Lake Lava Flows, Hat Creek Rim	1	PIT RIVER	0	2	Siskiyou, Shasta	91	0	0	0	0	0	0	0	9
791	3	Western Jurassic, Rattlesnake Creek, Eastern Franciscan	1	TRINITY RIVER	0	2	Humboldt, Trinity	94	4	0	2	0	0	0	0	0
792	2	Eastern Klamath Mountains, Upper Scott Mountains	4	SHASTA BALLY, SHASTA DAM, TRINITY RIVER, UPPER SACRAMENTO	0	2	Trinity, Shasta	81	12	0	1	3	1	0	0	2
793	2	High Cascade, Hat Creek Rim	1	MC CLOUD RIVER	0	1	Siskiyou	94	0	0	3	0	0	0	0	3
794	1	Medicine Lake Lava Flows	1	PIT RIVER	0	1	Siskiyou	92	8	0	0	0	0	0	0	0
795	2	Eastern Klamath Mountains, Upper Scott Mountains	1	UPPER SACRAMENTO	0	2	Siskiyou, Shasta	86	8	0	1	0	0	0	0	4
796	2	Medicine Lake Lava Flows, Medicine Lake Highlands	1	PIT RIVER	0	1	Siskiyou	16	0	0	0	0	0	0	0	84
797	4	Goose Lake Basin, Warner Mountains, Pit River Valley, Surprise Valley	3	LAKEVIEW, PIT RIVER, SUPRISE VALLEY	0	1	Modoc	60	27	8	4	0	0	0	1	1
798	1	High Cascade	1	MC CLOUD RIVER	0	1	Siskiyou	82	10	0	5	0	0	0	0	4
799	2	Eastern Klamath Mountains, Upper Scott Mountains	3	KLAMATH RIVER, TRINITY RIVER, UPPER SACRAMENTO	0	2	Siskiyou, Trinity	87	9	0	2	0	0	0	0	2
800	1	High Cascade	2	KLAMATH RIVER, MC CLOUD RIVER	0	1	Siskiyou	72	25	0	1	0	0	0	0	2
801	2	Central Franciscan, Central Franciscan	4	KLAMATH RIVER, MAD RIVER, REDWOOD CREEK, TRINIDAD	43	1	Humboldt	92	3	2	0	0	0	0	0	3
802	3	Medicine Lake Lava Flows, Devil's Garden, Mowitz Buttes	2	KLAMATH RIVER, PIT RIVER	0	1	Modoc	30	70	0	0	0	0	0	0	0
803	2	Goose Lake Basin, Warner Mountains	1	LAKEVIEW	0	1	Modoc	0	0	1	4	63	0	2	30	0
804	1	Medicine Lake Lava Flows	1	KLAMATH RIVER	0	1	Modoc	1	98	0	0	0	0	0	0	0
805	2	Medicine Lake Lava Flows, Medicine Lake Highlands	2	KLAMATH RIVER, PIT RIVER	0	2	Siskiyou, Modoc	60	3	2	0	0	0	0	0	35
806	2	Scott Valley, Upper Scott Mountains	2	KLAMATH RIVER, TRINITY RIVER	0	2	Siskiyou, Trinity	69	29	0	1	0	0	0	0	1
807	2	Upper Salmon Mountains, Forks of Salmon	1	KLAMATH RIVER	0	1	Siskiyou	94	2	0	2	1	0	0	0	1
808	3	Shasta Valley, High Cascade, Hat Creek Rim	3	KLAMATH RIVER, MC CLOUD RIVER, UPPER SACRAMENTO	0	1	Siskiyou	68	4	1	2	0	0	0	0	24
809	1	Eastern Franciscan	1	KLAMATH RIVER	0	1	Humboldt	97	1	0	2	0	0	0	0	0
810	1	Medicine Lake Lava Flows	1	KLAMATH RIVER	0	2	Siskiyou, Modoc	75	24	0	0	0	0	0	0	0
811	3	Upper Salmon Mountains, Upper Scott Mountains, Forks of Salmon	1	KLAMATH RIVER	0	1	Siskiyou	94	1	2	0	0	1	0	0	2
812	4	Devil's Garden, Crowder Flat, Goose Lake Basin, Pit River Valley	3	KLAMATH RIVER, LAKEVIEW, PIT RIVER	0	1	Modoc	15	72	3	6	3	0	0	1	0
813	3	Warner Mountains, Sheldon Range, Surprise Valley	3	COW HEAD LAKE, LAKEVIEW, SUPRISE VALLEY	0	1	Modoc	14	52	15	10	0	0	0	1	7
814	5	Lower Klamath-Tule Lake Basins, Devil's Garden, Crowder Flat, Mowitz Buttes, Pit River Valley	2	KLAMATH RIVER, PIT RIVER	0	1	Modoc	21	73	1	4	0	0	0	0	0
815	10	Upper Scott Mountains, Trinity Mountain-Hayfork, North Trinity Mountain, Oregon Mountain, Forks of Salmon, Upper Salmon Mountains, Western Jurassic, Lower Salmon Mountains, and 2 others	2	KLAMATH RIVER, TRINITY RIVER	0	3	Siskiyou, Humboldt, Trinity	92	4	1	0	0	0	0	0	2
816	3	Humboldt Bay Flats and Terraces, Central Franciscan, Central Franciscan	1	TRINIDAD	0	1	Humboldt	22	0	4	5	59	1	0	0	8
817	3	Medicine Lake Lava Flows, Lower Klamath-Tule Lake Basins, Devil's Garden	1	KLAMATH RIVER	0	2	Siskiyou, Modoc	7	90	0	0	0	0	0	0	2
818	1	Scott Valley	1	KLAMATH RIVER	0	1	Siskiyou	57	24	10	0	0	0	1	2	6
819	2	Medicine Lake Lava Flows, Lower Klamath-Tule Lake Basins	1	KLAMATH RIVER	0	2	Siskiyou, Modoc	14	60	0	0	0	0	0	0	26
820	3	Northern Franciscan, Central Franciscan, Central Franciscan	3	KLAMATH RIVER, REDWOOD CREEK, TRINIDAD	0	1	Humboldt	90	2	1	0	0	1	0	0	5
821	2	Medicine Lake Lava Flows, Lower Klamath-Tule Lake Basins	1	KLAMATH RIVER	0	2	Siskiyou, Modoc	0	15	0	2	0	2	41	40	0
822	1	Shasta Valley	1	KLAMATH RIVER	0	1	Siskiyou	0	17	1	2	0	0	65	15	0

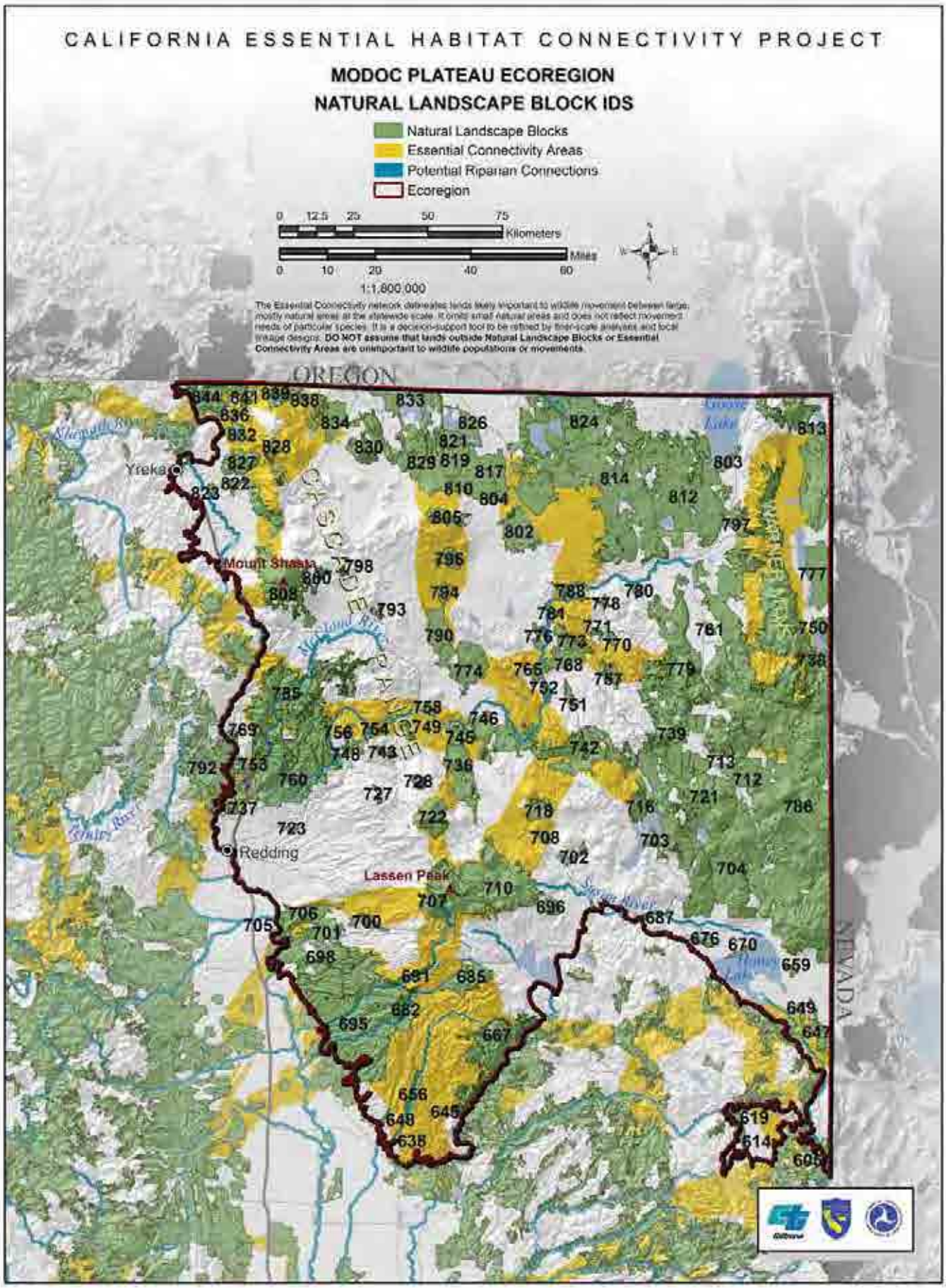
Characteristics of Natural Landscape Blocks

ID	NLB_Name	elev_MEAN	elev_MIN	elev_MAX	elev_STD	elev_RANGE	mn_integ	std_integ	AREA_ac	AREA_km2	pc_protect	pc_gap12e	pc_gap3	pc_privunp	mn_sprich	std_sprich	CNDDB_plant_count	CNDDB_animal_count	pc_hotspt	pc_crithab	crithab_sp_count	pc_esshab	esshab_sp_count	pc_wtvp	n_ecoreg	Ecoregs
823		793	762	851	17	89	93	12	2,088	8	22	3	19	78	265	2	1	2	0	0	0	0	0	7	1	MODOC PLATEAU
824		1,446	1,256	1,756	70	500	97	13	130,956	530	95	24	71	5	250	8	8	14	0	0	0	0	0	5	1	MODOC PLATEAU
825	Redwood/ Williams Ridge/ Holter Ridge	439	7	935	193	928	88	22	45,882	186	28	28	0	72	244	4	12	12	0	0	0	0	0	0	1	NORTH COAST
826		1,229	1,227	1,243	1	16	1	7	13,402	54	100	100	0	0	241	6	0	4	0	0	0	0	0	1	1	MODOC PLATEAU
827	Martin Hill	1,081	814	1,738	189	924	92	15	36,491	148	9	0	9	91	266	11	5	2	0	0	0	0	0	0	1	MODOC PLATEAU
828		1,839	1,222	2,521	298	1,299	91	16	7,406	30	66	0	66	34	264	8	3	2	0	39	1	0	0	0	1	MODOC PLATEAU
829		1,411	1,233	1,982	101	749	93	18	70,949	287	87	40	48	13	250	11	6	11	15	0	0	0	0	1	1	MODOC PLATEAU
830		1,462	1,262	1,889	130	627	93	17	37,265	151	55	1	54	45	247	9	2	4	0	0	0	0	0	0	1	MODOC PLATEAU
831		251	31	492	104	461	68	36	5,278	21	99	99	0	1	243	1	3	5	0	80	1	0	0	1	1	NORTH COAST
832		993	740	1,374	148	634	93	11	7,007	28	0	0	0	100	252	6	1	0	0	0	0	0	0	0	1	MODOC PLATEAU
833		1,244	1,239	1,300	2	61	25	40	26,712	108	96	96	0	4	244	7	0	11	2	0	0	0	0	39	1	MODOC PLATEAU
834	Butte Valley	1,311	1,287	1,537	43	250	90	22	26,107	106	76	61	15	24	265	7	0	2	0	0	0	0	0	1	1	MODOC PLATEAU
835		1,022	615	1,625	200	1,010	96	10	2,051	8	85	0	85	15	237	0	0	0	0	0	0	0	0	1	1	NORTH COAST
836		813	729	893	33	164	90	16	2,290	9	0	0	0	100	245	1	0	0	0	0	0	0	0	0	1	MODOC PLATEAU
837		939	565	1,486	180	921	86	27	9,342	38	79	12	67	21	240	3	0	2	0	0	0	0	0	1	2	MODOC PLATEAU, NORTH COAST
838	Panther Canyon	1,230	798	1,729	239	931	90	17	9,655	39	42	0	42	58	269	5	1	6	0	12	1	0	0	0	1	MODOC PLATEAU
839		976	787	1,171	109	384	84	25	2,478	10	11	0	11	89	269	3	0	4	0	0	0	0	0	2	1	MODOC PLATEAU
840	Gold Bluffs	114	0	305	67	305	66	34	18,991	77	97	97	0	3	266	19	11	11	0	45	1	0	0	3	1	NORTH COAST
841		916	705	1,141	90	436	92	13	2,937	12	0	0	0	100	261	10	0	2	0	0	0	0	0	0	1	MODOC PLATEAU
842	Little Cottonwood Pk	1,011	590	1,909	212	1,319	92	18	12,978	53	58	0	58	42	240	6	0	2	0	0	0	0	0	0	1	NORTH COAST
843	Marble Mountains	1,411	184	2,511	412	2,327	88	18	349,289	1,414	98	89	9	2	228	8	26	14	0	14	1	0	0	0	1	NORTH COAST
844	Wadsworth Flat	929	669	1,331	126	662	91	16	26,560	107	30	4	26	70	252	6	4	7	0	0	0	0	0	0	1	MODOC PLATEAU
845		689	381	1,130	169	749	95	12	2,058	8	96	0	96	4	232	1	0	1	0	0	0	0	0	0	1	NORTH COAST
846		203	0	397	105	397	32	31	3,919	16	100	100	0	0	279	26	11	3	6	74	1	0	0	1	1	NORTH COAST
847	Siskiyou Mountains	1,288	400	2,160	336	1,760	89	19	95,968	388	99	82	17	1	226	7	10	2	0	50	2	0	0	0	1	NORTH COAST
848	Dillon Divide	908	2	2,204	393	2,202	83	23	512,291	2,073	96	83	12	4	231	11	61	21	9	34	2	0	0	0	1	NORTH COAST
849		8	0	25	4	25	64	34	2,014	8	99	99	0	1	305	3	9	5	83	0	0	0	1	28	1	NORTH COAST
850		621	50	1,158	215	1,108	73	23	86,293	349	86	86	0	14	234	15	29	12	66	12	2	0	0	0	1	NORTH COAST

Characteristics of Natural Landscape Blocks

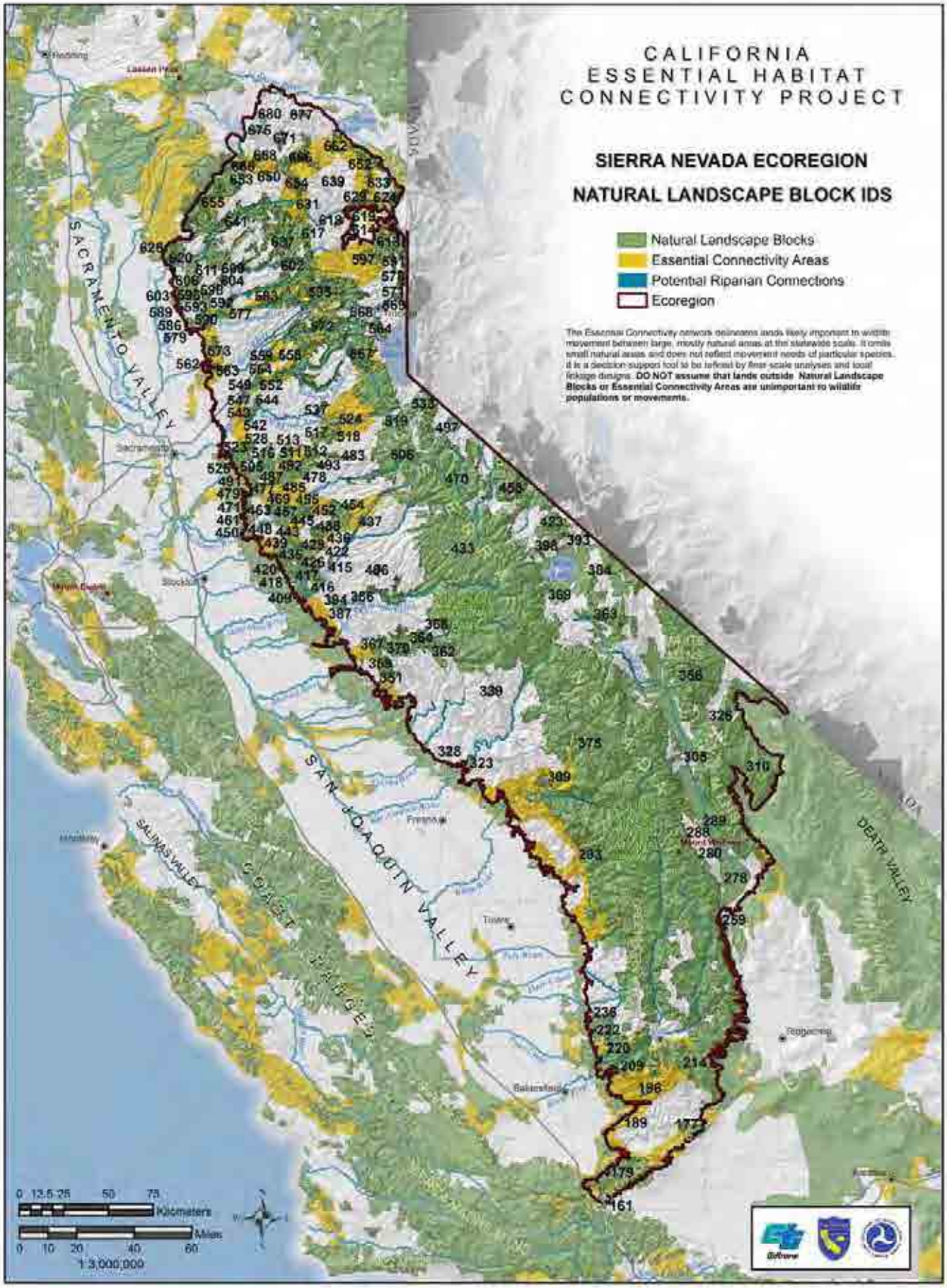
ID	n_subsect	Subsect	HU_num	HU_names	pc_blmacec	n_Counties	Counties	pc_forest	pc_shrub	pc_herb	pc_wetrip	pc_water	pc_dev	pc_crop	pc_pasture	pc_other
823	1	Shasta Valley	1	KLAMATH RIVER	0	1	Siskiyou	1	67	8	0	0	0	11	8	5
824	3	Lower Klamath-Tule Lake Basins, Devil's Garden, Crowder Flat	1	KLAMATH RIVER	0	1	Modoc	19	73	1	5	1	0	0	0	0
825	3	Northern Franciscan, Eastern Franciscan, Central Franciscan	2	KLAMATH RIVER, REDWOOD CREEK	0	1	Humboldt	94	2	1	0	0	1	0	0	2
826	2	Medicine Lake Lava Flows, Lower Klamath-Tule Lake Basins	1	KLAMATH RIVER	0	2	Siskiyou, Modoc	0	0	0	1	5	4	24	66	0
827	2	Old Cascades, Shasta Valley	1	KLAMATH RIVER	0	1	Siskiyou	26	65	0	3	0	0	2	2	1
828	2	Old Cascades, High Cascade	1	KLAMATH RIVER	0	1	Siskiyou	95	0	0	1	0	0	0	0	3
829	3	Medicine Lake Lava Flows, Medicine Lake Highlands, Lower Klamath-Tule Lake Basins	1	KLAMATH RIVER	0	1	Siskiyou	24	66	0	1	0	0	0	1	8
830	1	Medicine Lake Lava Flows	1	KLAMATH RIVER	0	1	Siskiyou	72	24	0	1	0	0	0	2	0
831	1	Northern Franciscan	2	KLAMATH RIVER, REDWOOD CREEK	0	2	Del Norte, Humboldt	97	1	1	0	0	1	0	0	0
832	1	Old Cascades	1	KLAMATH RIVER	0	1	Siskiyou	25	71	0	4	0	0	0	0	0
833	2	Medicine Lake Lava Flows, Lower Klamath-Tule Lake Basins	1	KLAMATH RIVER	0	1	Siskiyou	0	1	0	23	6	0	0	68	1
834	2	High Cascade, Medicine Lake Lava Flows	1	KLAMATH RIVER	0	1	Siskiyou	18	70	3	5	0	0	1	2	0
835	1	Scott Bar Mountain	1	KLAMATH RIVER	0	1	Siskiyou	86	11	0	1	0	1	0	0	0
836	1	Old Cascades	1	KLAMATH RIVER	0	1	Siskiyou	29	66	0	5	0	0	0	0	0
837	1	Scott Bar Mountain	1	KLAMATH RIVER	11	1	Siskiyou	68	27	1	2	0	0	0	2	0
838	2	Old Cascades, High Cascade	1	KLAMATH RIVER	0	1	Siskiyou	87	10	0	2	0	0	0	0	0
839	1	Old Cascades	1	KLAMATH RIVER	0	1	Siskiyou	24	64	2	8	1	0	1	0	1
840	2	Northern Franciscan, Central Franciscan	3	KLAMATH RIVER, REDWOOD CREEK, SMITH RIVER	0	2	Del Norte, Humboldt	83	6	2	2	1	3	0	0	4
841	1	Old Cascades	1	KLAMATH RIVER	0	1	Siskiyou	33	60	0	4	3	0	0	0	0
842	1	Scott Bar Mountain	1	KLAMATH RIVER	0	1	Siskiyou	63	35	1	1	0	0	0	0	0
843	5	Western Jurassic, Scott Bar Mountain, Lower Salmon Mountains, Upper Salmon Mountains, Forks of Salmon	1	KLAMATH RIVER	0	1	Siskiyou	92	5	1	0	0	0	0	0	1
844	2	Scott Bar Mountain, Old Cascades	1	KLAMATH RIVER	3	1	Siskiyou	45	51	0	4	0	0	0	0	0
845	2	Western Jurassic, Siskiyou Mountains	1	KLAMATH RIVER	0	1	Siskiyou	95	3	0	0	0	1	0	0	1
846	1	Northern Franciscan	1	SMITH RIVER	0	1	Del Norte	76	9	5	1	3	7	0	0	2
847	5	Western Jurassic, Siskiyou Mountains, Scott Bar Mountain, Lower Salmon Mountains, Windy Peak	2	KLAMATH RIVER, ROGUE RIVER	0	1	Siskiyou	94	4	0	1	0	0	0	0	1
848	6	Northern Franciscan, Western Jurassic, Gasquet Mountain Ultramafics, Siskiyou Mountains, Lower Salmon Mountains, Eastern Franciscan	3	KLAMATH RIVER, ROGUE RIVER, SMITH RIVER	0	3	Del Norte, Siskiyou, Humboldt	93	3	0	0	0	2	0	0	1
849	1	Northern Franciscan	1	SMITH RIVER	0	1	Del Norte	39	0	42	4	0	2	5	5	4
850	3	Northern Franciscan, Western Jurassic, Gasquet Mountain Ultramafics	3	ROGUE RIVER, SMITH RIVER, WINCHUCK RIVER	0	1	Del Norte	76	21	0	0	0	2	0	0	1

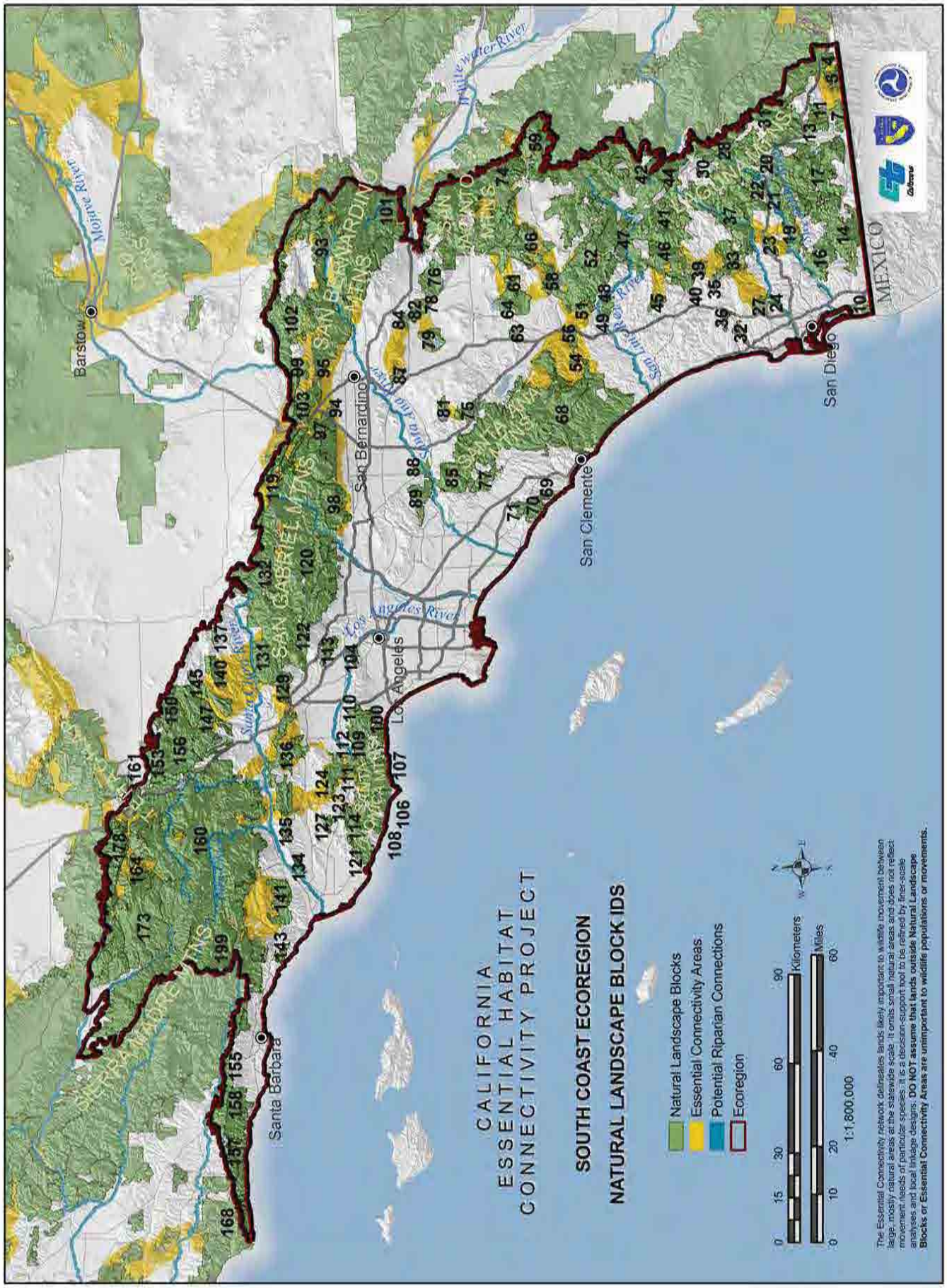
OREGON
Crescent City
Yreka
Mount Shasta
Eureka
Redding
Fort Bragg
Pt Reyes
CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
NORTH COAST ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:2,000,000
This Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

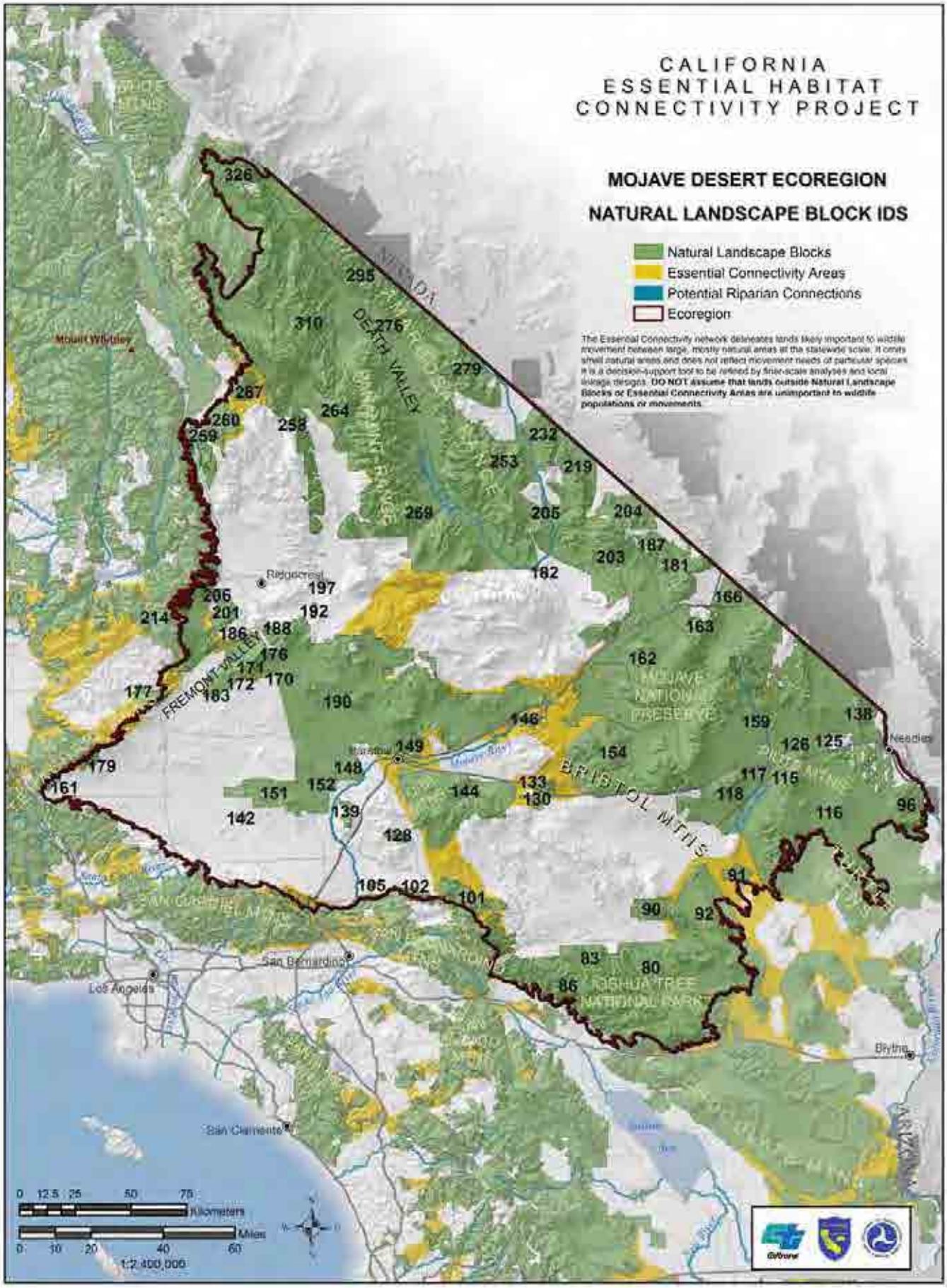

CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT
MODOC PLATEAU ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 12.5 25 50 75
Kilometers
Miles
0 10 20 40 60
1:1,800,000
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
OREGON
NEVADA
Yreka
Mount Shasta
Redding
Lassen Peak

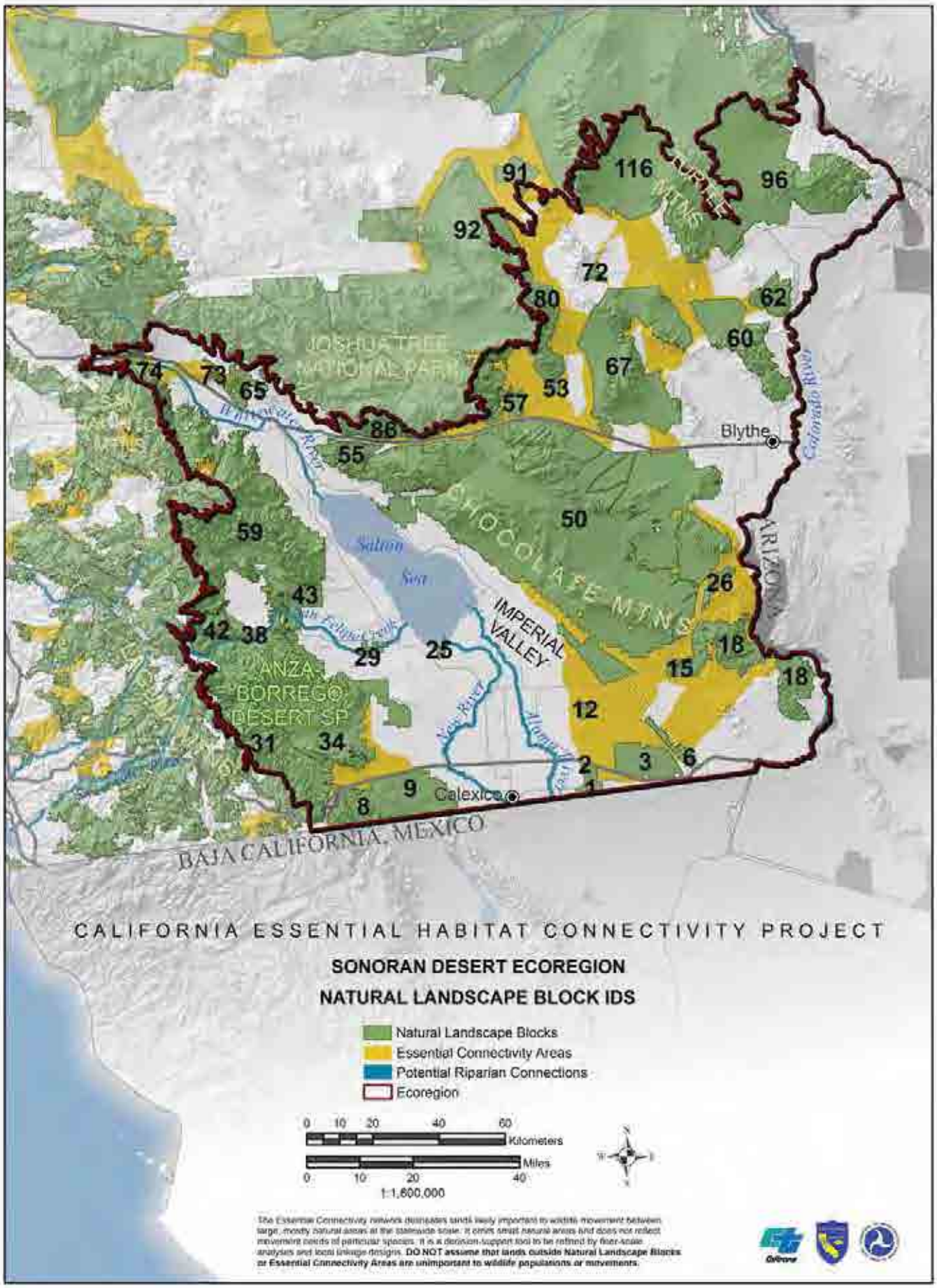
CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
CENTRAL COAST ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
Kilometers
Miles
1:2,500,000
Sacramento
Stockton
Fresno
Tulare
Bakersfield
Santa Barbara
Monterey
Pt Reyes
SAN JOAQUIN VALLEY
SALINAS VALLEY
DIABLO RANGE
SIERRA MADRE
DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.

CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
CENTRAL VALLEY ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
SACRAMENTO VALLEY
SAN JOAQUIN VALLEY
COAST RANGE
SALINAS VALLEY
Redding
Lassen Park
Sacramento
Stockton
Fresno
Tulare
Bakersfield
Monterey
Truckee
Ridgecrest
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas in the statewide scale. It maps small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by landscape analyses and local village designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
0 12.5 25 50 75 Kilometers
0 10 20 40 60 Miles
1:3,000,000


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
SIERRA NEVADA ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision support tool to be refined by finer scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
SACRAMENTO VALLEY
SAN JOAQUIN VALLEY
SALINAS VALLEY
COAST RANGE
DEATH VALLEY
Sacramento
Stockton
Fresno
Tulare
Bakersfield
Ridgecrest
Lassen Peak
Mount Whitney
0 12.5 25 50 75
Kilometers
0 10 20 40 60
Miles
1:3,000,000


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
SOUTH COAST ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
Kilometers
Miles
1:1,800,000
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
Barstow
Mojave River
Santa Barbara
San Bernardino
Los Angeles
San Clemente
San Diego
MEXICO
Los Angeles River
San Luis Rey River
Santa Ana River
Santa Clara River
Mojave River
Whitewater River


CALIFORNIA
ESSENTIAL HABITAT
CONNECTIVITY PROJECT
MOJAVE DESERT ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
Mount Whitney
DEATH VALLEY
Ridgecrest
FREMONT VALLEY
MOJAVE NATIONAL PRESERVE
BRISTOL MTNS
Needles
San Bernardino
Los Angeles
JOSHUA TREE NATIONAL PARK
Blythe
San Clemente
0 12.5 25 50 75 Kilometers
0 10 20 40 60 Miles
1:2,400,000


CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT
SONORAN DESERT ECOREGION
NATURAL LANDSCAPE BLOCK IDS
Natural Landscape Blocks
Essential Connectivity Areas
Potential Riparian Connections
Ecoregion
0 10 20 40 60
Kilometers
Miles
0 10 20 40
1:1,600,000
The Essential Connectivity network delineates lands likely important to wildlife movement between large, mostly natural areas at the statewide scale. It omits small natural areas and does not reflect movement needs of particular species. It is a decision-support tool to be refined by finer-scale analyses and local linkage designs. DO NOT assume that lands outside Natural Landscape Blocks or Essential Connectivity Areas are unimportant to wildlife populations or movements.
JOSHUA TREE NATIONAL PARK
Blythe
Calexico
Salton Sea
IMPERIAL VALLEY
CHOCOLATE MTNS
ANZA BORREGO DESERT SP
BAJA CALIFORNIA, MEXICO
ARIZONA
Colorado River
116
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6
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1
8

Appendix D: List of Acronyms

AB2785	California Assembly Bill 2785 *(requires CDFG to map essential wildlife corridors and habitat linkages)*
ACE	Areas of Conservation Emphasis *(defined by CDFG)*
ACEC	Areas of Critical Environmental Concern *(designated by BLM)*
BLM	United States Bureau of Land Management
Caltrans	State of California Department of Transportation
CEHCP	California Essential Habitat Connectivity Project
CEQA	California Environmental Quality Act
CBI	Conservation Biology Institute
CDFG	State of California Department of Fish and Game
CNDDB	California Natural Diversity Database
CPAD	California Protected Area Database
CRCC	California Rangeland Conservation Coalition
CWHR	California Wildlife Habitat Relationships
DEM	Digital Elevation Model
DFG	State of California Department of Fish and Game
DOD	United States Department of Defense
ECA	Essential Connectivity Areas
ECI	Ecological Condition Index
FHWA	Federal Highways Administration
FRAP	California Department of Forestry and Fire Protection's Fire and Resource Assessment Program
FWS	See USFWS
GAP	Gap Analysis Program (*A GAP analysis compares the distributions of species and communities with the protection status of lands. http://gapanalysis.nbii.gov)*
GIS	Geographic Information System
HBV	High Biological Value
HCP	Habitat Conservation Plan
IIC	Integral Index of Connectivity
IWA	Integrity Weighted Area
LCC	Least Cost Corridor
MDT	Multi-disciplinary Team
MPO	Metropolitan Planning Organizations
NCCP	Natural Community Conservation Plans
NGO	Non-Governmental Organization
NLB	Natural Landscape Block
RTPA	Regional Transportation Planning Agencies
RWRI	Rarity-Weighted Richness Index
SAFETEA-LU	Safe Accountable Flexible Efficient Transportation Equity Act of 2005
SB375	California Senate Bill 375 *(requires regional transportation plans to include strategies to meet goals for reducing greenhouse gas emissions)*

SB85	California Senate Bill 85 *(requires CDFG to develop vegetation mapping standards)*
SCML	South Coast Missing Linkages
SCW	SC Wildlands (Science and Collaboration for Connected Wildlands)
SWAP	State Wildlife Action Plan
TAG	Technical Advisory Group
TIGER	United States Census Bureau Topologically Integrated Geographic Encoding and Referencing system
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WCB	Wildlife Conservation Board
WGA	Western Governor's Association
WGWC	Western Governor's Wildlife Council
WRP	Western Regional Partnership

Appendix E: New Approaches to Analysis of Connectivity

This Report used several Geographic Information System (GIS) based procedures to delineate Natural Landscape Blocks and Essential Connectivity Areas. The most important tool for defining essential connectivity areas was least-cost modeling. In this appendix, we briefly describe two relatively new approaches that are relevant to design of corridors and linkages.

Individual-based movement models

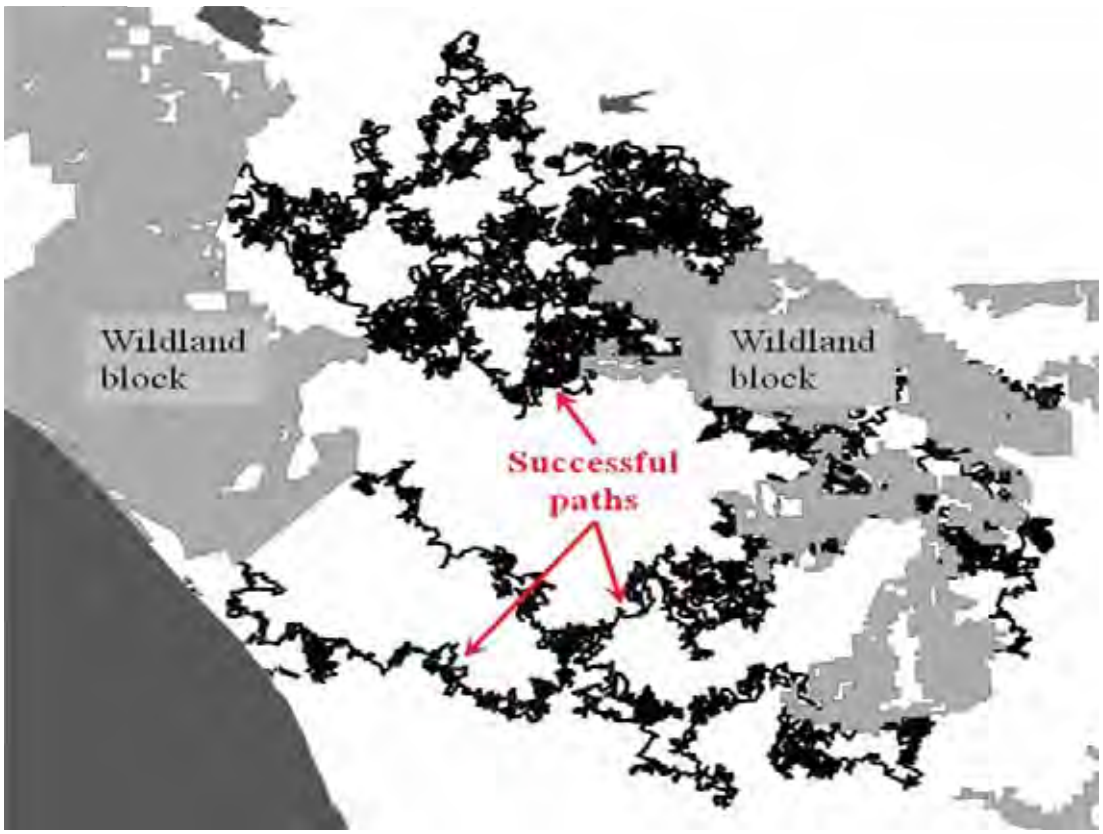
In this approach, the landscape is portrayed in a Geographic Information System as a grid of squares; such a grid is called a *raster*, and each square is called a *pixel*. Each pixel has attributes, such as land cover, topography, and level of human disturbance. The analyst uses these attributes to define polygons (e.g., steep, suburbanized land, or flat, natural land) that are relevant to focal species. These polygons must be set separately for each focal species, because a given polygon (e.g., steep urbanized land) does not affect movement of every species in the same way. The analyst also uses pixel attributes to estimate the energy cost of traveling through the pixel. This "energy cost map" is exactly analogous to the "resistance map" in least-cost modeling.

For each focal species, the analyst then (based on observations of animal movement, or expert opinion) estimates movement parameters, such as the probability that an animal will continue in one direction or choose a new direction at each time interval, travel speed, mean turning angles, and risk of mortality. Each of these parameters can depend on pixel resistance, or the type of polygon in which the animal is located.

The analyst also develops decision rules that govern how an animal's movement changes as it approaches the boundary of each other type of polygon. Most of these rules are probabilistic (e.g., go straight ahead 60% of the time, right 20% of the time, and left 20% of the time) so that simulated paths can mimic real animals exploring a landscape. Many decision rules are habitat-specific, meaning that the rule is different in each polygon type.

Then the analyst models the release of thousands of simulated animals (*walkers*) in each wildland block, and follows the movement path of each walker for a certain number of time steps. After that number of time steps the walker has either died, remained in the wildland block where it started, or reached the other wildland block. The analyst retains only the paths that successfully reached the other wildland block. These paths represent potential linkages for that focal species. The analyst identifies areas with the highest density of successful paths, or polygons that are most visited, or uses some other procedure to delineate a corridor that is more coherent than the many successful paths.

The map below (from Tracey 2006) illustrates this approach applied to mountain lions potentially moving between the Santa Ana Mountains (west) and the Palomar Mountains (east) in southern California.



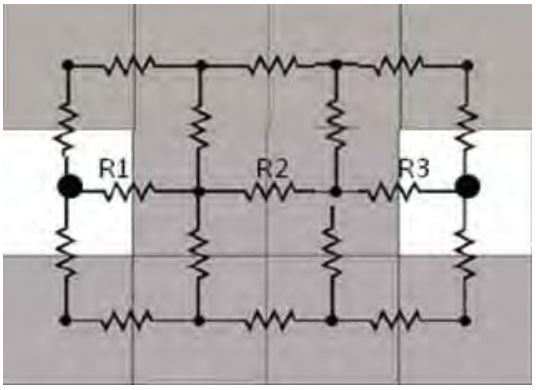
The individual-based movement has several advantages. First, it simulates animal movement, which is highly relevant to corridor design. Furthemore, the model considers the impact of mortality on successful movement, an important relationship ignored by least cost modeling and circuit theory. Finally, it identifies multiple possible paths that are less linear than those produced by least-cost modeling. The main disadvantage of the approach is that ecologists rarely have data to estimate the many parameters in the model. Global Positioning System (GPS) radio-tags will probably soon yield the type of data, and sufficient volumes of data, to estimate these parameters reliably. If a reliably-parameterized model is available, we believe this is an ideal tool for identify wildlife corridors. Although this approach has not yet been used to design a wildlife linkage, we expect that it will become popular in the future. .

Key citations:

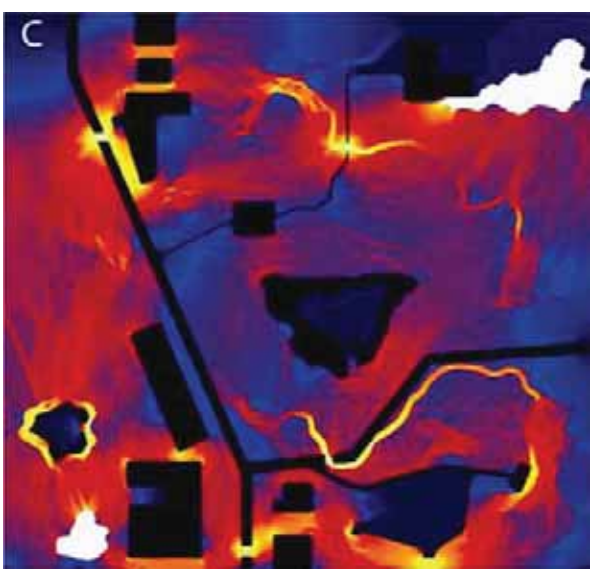
Hargrove, W. W., F. M. Hoffman, and R. A. Efroymson. 2004. A practical map-analysis tool for detecting potential dispersal corridors. Landscape Ecology 20:361-373.

Tracey, JA. 2006. Individual-based modeling as a tool for conserving connectivity. Pages 343-368 (Chapter 14) in KR Crooks and MA Sanjayan. Connectivity Conservation. Cambridge University Press.

Circuit Theory



In circuit theory, each pixel is connected to adjacent pixels by resistors (—⧫⧫⧫—). Resistances are proportional to the difficulty of moving. Two wildland blocks (white pixels) can exchange dispersers via all resistors in the network. Following Kirchhoff's (1845) laws, for resistors connected in series, resistance accumulates as the sum of those resistances (e.g. $R_T = R_1 + R_2 + \ldots R_N$), and so cost-weighted distance increases with map distance. For resistors connected in parallel, $R_{Total} = R_1 * R_2 / (R_1 + R_2)$. Thus cumulative resistance decreases (and movement of animals increases) when multiple paths are available.



Circuit theory is a new approach that was created to *describe* patterns of gene flow and animal movement, rather than to design a linkage. It portrays the landscape in a Geographic Information System as a grid of squares; such a grid is called a *raster*, and each square is called a *pixel*. The analyst assigns resistance values to each pixel as a function of pixel attributes, such as land cover, topography, and level of human disturbance. These resistance values must be set separately for each focal species, because a given attribute (e.g., percent forest cover) does not affect movement of every species in the same way. This resistance raster is similar to the resistance raster used in least-cost modeling in that they are typically estimated by expert opinion and the literature on habitat use. However, the resistance values in circuit theory are interpreted as movement probabilities (or their reciprocal) rather than energetic cost. The key innovation of circuit theory is that it considers the ability of the *entire landscape* to support animal movement (panel and caption).

In a typical use of a circuit theory model, the analyst applies a "current source" at one wildland block and a "ground" at the other wildland block and solves for "current flow," which is analogous to the number of animals passing through each pixel as they disperse from one wildland block to the other. An area where movement is channeled into a narrow areas (pinchpoint) glows brightly. In the adjacent panel, the Wildland Blocks (current source/ground) are white, hot colors (yellow) indicate high per-pixel movement rates, and blue colors indicate low movement rates.

The advantages of circuit theory are that it reflects the potential for the entire landscape

to support animal movement as a graded map, rather than a polygon that categorizes every pixel as either inside or outside the corridor. The maps are visually attractive, Pinchpoints represent vulnerable points along the linkage. It has exactly the same modest data requirements as least-cost modeling.

Although a circuit theory map conveys a lot of information about landscape connectivity, the map does not identify a distinct corridor. Indeed, a polygon that includes areas of highest flow under current conditions may make a poor corridor, because its potential to support movement will decrease (in unpredictable ways) when land outside the corridor is impacted by development. In contrast, the utility of a least-cost corridor does not change when land outside the corridor is converted to non-natural vegetation.

The second drawback is that circuit theory depiction of flow may not highlight the best area to conserve as a linkage. Consider the Figure below, with two linkages connecting the Wildland Blocks (white rectangles). The linkage at left has a pinchpoint, evident as a "hot" area of constricted flow. But the linkage at right is an area of broad unimpeded flow, and would be a better linkage to conserve. Ecologists have not yet developed metrics and decision rules to define unambiguous linkage polygons using circuit theory. Recall that circuit theory was developed as a way to describe movement. It will take some time for it to evolve into an approach to prescribe optimal linkages.

In its current state of development, circuit theory is probably the best way to depict connectivity across an entire landscape, and it usefully identifies the degree of threat facing a linkage. For instance, the linkage on the left is clearly more at risk than the one on the right.

Key papers:

McRae, B.H. 2006. Isolation by resistance. Evolution 60:1551-1561.

McRae, B.H. and P.Beier. 2007. Circuit theory predicts gene flow in plant and animal populations. Proceedings of the National Academy of Sciences of the United States of America 104:19885-19890

McRae, BH, BG Dickson, T. Keitt and VB Shah. 2008. Using circuit theory to model connectivity in ecology, evolution, and conservation. Ecology 89:2712-2724.

Comprehensive Conservation and Management Plan

For the Morro Bay Estuary

2012 Draft

Prepared by: Morro Bay National Estuary Program

Morro Bay, CA

*This is a draft document released by the Morro Bay National Estuary Program to gather public comment and input on the document. **The public comments period ends April 13, 2012.** The final document will be released upon approval by the Estuary Program's Management Committees in fall 2012. To best incorporate a wide range of comments and suggestions, the draft document has been left with little formatting or illustrations. The final document will include additional figures, pictures, charts, and other formatting components to make the document easier to read and reference. Therefore, the Estuary Program requests that comments focus on the content of the document, not the formatting. In addition, the Estuary Program encourages readers to focus their attention on Chapter 3, the action plans chapter. The action plans are the heart of the document and represent the strategic direction for the Estuary Program and its partners for future conservation and restoration efforts. Thank you for your time and consideration in providing comments on this document. If you have any questions or concerns throughout the comment period, please contact Assistant Director Lexie Bell at lbell@mbnep.org or 805-772-3834, ext. 16.*

Executive Summary

The Comprehensive Conservation and Management Plan (CCMP) defines the priority issues facing the health of the Morro Bay estuary and watershed and presents action plans to effectively address those issues. The CCMP is the guiding document for the Morro Bay National Estuary Program (Estuary Program). The Estuary Program is a collaborative, non-regulatory, nonprofit organization that brings citizens, local governments, non-profit organizations, state and federal agencies, and landowners together to protecting and restore the Morro Bay Estuary.

The Estuary Program has four watershed goals:

- Water Quality Protection and Enhancement – Water quality in the Morro Bay watershed and estuary supports diverse habitats and wildlife populations, recreation, clean drinking water, and well-balanced economic uses.
- Ecosystem Restoration and Conservation – The Morro Bay watershed and estuary sustain a resilient community with high habitat connectivity, ample biological integrity, proper ecosystem function, and a vibrant economy.
- Public Education, Outreach, and Stewardship – Citizens and visitors around Morro Bay understand basic estuary science and the impacts of specific actions on estuary health, and are engaged stewards of the Morro Bay estuary and watershed.
- Fostering Collaboration – Local citizens, local government, non-profits, state and federal agencies, and public and private landowners collaborate and leverage resources to facilitate effective management and increased scientific knowledge of the Morro Bay estuary and watershed.

The CCMP describes seven priority issues impacting the health of the Morro Bay estuary and watershed. These issues were identified through grassroots public participation, scientific study, and more than a decade of conservation and restoration experience. The priority issues, explained in detail in Chapter 2, are

- Accelerated sedimentation
- Bacterial contamination
- Elevated nutrient levels
- Toxic pollutants
- Scarce freshwater resources
- Preserving biodiversity
- Environmentally balanced uses

Over the next five years, the Estuary Program will prioritize its work and support for partners on the seven priority issues into specific focus areas. The focus areas are not meant to limit the Estuary Program or its partners but instead to provide strategic direction about what projects and partnerships to pursue. The focus areas are described with more detail in the beginning of Chapter 3.

Sedimentation Focus Areas

- Floodplains
- Riparian buffers
- Upland erosion sources

Bacteria Focus Areas

- Disposal of waste in the estuary
- Stormwater management
- Determining bacteria sources in specific areas

Nutrients Focus Areas

- Reducing nutrient loads in Los Osos valley from agricultural sources
- Monitoring efforts to track changes in bay water quality

- Stormwater Management

Toxics Focus Areas

- Marina and boat-related toxics
- Education to reduce toxics use near the bay
- Emerging contaminants

Freshwater Flow Focus Areas

- Water budgets
- Integrated water management
- Water conservation and education
- Increase infiltration

Biodiversity Focus Areas

- Management of invasive species
- Supporting the integration of disparate planning efforts that impacts habitats and biodiversity in the Morro Bay watershed
- Increasing the understanding of reference conditions to inform effective restoration

Environmentally Balanced Uses Focus Areas

- Over the next five years, the Estuary Program will focus on determining the key areas of concern under this priority issue and developing approaches to address them. The Estuary Program will gather input from local stakeholders, including resource managers, the general public, and specific user groups, to determine their concerns about balancing a variety of uses in the watershed while maintaining and healthy and robust environment. At the end of this time period, the Estuary Program anticipates completing a well-developed plan outlining the organization's role in addressing this priority issue and implementation actions that can be taken to fulfill that role.

To address the priority issues and their focus areas for the next five years, the CCMP outlines a number of action plans to bring about positive environmental change in the watershed and estuary. Many of these actions plans are based on those described in the 2001 CCMP; some are new action plans to address new and emerging issues or techniques. All of the action plans are presented in Chapter 3 and are organized based on general type of action. Each action plan can address multiple priority issues and focus areas. The action plans are tools to achieve conservation success and they will be implemented as they are relevant to the focus areas and priority issues of the Estuary Program. The Estuary Program prepares an annual workplan that specifies the action plans to be implemented each year.

Acknowledgements

The Estuary Program would like to thank the many individuals and organizations that have participated so far in the 2012 update to the CCMP.

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This updated document would not have been possible without the people and organizations that made the first CCMP possible. Hundreds of individuals donated countless hours to that first effort and created a strong document that provided 10 years of conservation direction to the Estuary Program. The individuals and organizations involved in the completion of the first CCMP are listed in the Appendices to this document.

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Chapter 1 Introduction

The Morro Bay estuary is a 2,300 acre semi-enclosed body of water where freshwater flowing from the land mixes with the saltwater of the sea. The estuarine system includes the lower reaches of Chorro and Los Osos creeks, a wide range of wetlands, salt and freshwater marshes, intertidal mud flats, eelgrass beds, and other subtidal habitats.

Morro Bay contains one of the most significant and least disturbed wetland systems on the central and southern California coast. It serves as a vital stopover and wintering ground for migratory birds and is home to a diverse assembly of habitats and plant and wildlife species, many of which are not found anywhere else in the world. The estuary and its watershed also support exceptional natural beauty and pleasing rural ambiance, and accommodate popular outdoor recreational activities. Residents and visitors enjoy fishing, birding, hiking, wildlife watching, mountain biking, camping, golfing, horseback riding, and a variety of water-based sports.

Economically, Morro Bay sustains a working harbor that supports both commercial enterprises and recreational boating. A growing tourism-based commercial sector has also developed around the estuary, providing employment and economic vitality. Many tourism-related activities incorporate recreation on the estuary as part of the Morro Bay experience. Other bay-dependent uses include commercial oyster cultivation and an electricity-generating power plant.

The watershed that drains into Morro Bay covers approximately 48,000 acres, or 75 square miles. It is composed of two major sub-watersheds that drain into Chorro and Los Osos creeks. The Chorro Creek sub-watershed accounts for about 60 percent of the total land area draining into the estuary. Much of the watershed remains in open space that is used primarily for agriculture and a range of public uses, including parks, golf courses, nature preserves, a military base, and university-owned rangeland (California Polytechnic University). The developed portions of the watershed include the community of Los Osos/Baywood Park, parts of the City of Morro Bay, Cuesta College, the California Men's Colony and various facilities of the County of San Luis Obispo.

Changes to the Bay

Both the bay and its watershed have been altered from their natural conditions by human activities.

The current form of the harbor area was largely set in the 1940s when the U.S. Navy requested Morro Bay be improved to serve as a training and coastal patrol base. Improvements by the Army Corps of Engineers included the reinforcement of the causeway between Morro Rock and the mainland (the causeway was originally built in 1911); installation of revetment to solidify the Embarcadero between Coleman and Tidelands parks; construction of the north and south jetty breakwaters; and dredging to deepen the main navigation channels. Later, a stone groin was added within the harbor mouth to capture littoral sand at the north end of the sand spit. In the 1950s, a power plant, which extracts cooling water from the estuary, was built near the harbor mouth. By the early 21st century, the operation of the power plant was largely reduced.

During the 20th century, the community of Los Osos developed on coastal dune habitat at the south end of the bay. In the city of Morro Bay, the harbor improvements built for the Navy were converted to civilian uses, and the Embarcadero evolved into a popular tourist area. The upper watershed was mined for chromium and nickel; oak savannah and scrub areas were converted to grazing land; and floodplains were cleared and diked for cropland. All of these activities contribute to accelerated erosion and sedimentation in the bay. Some impacts from these activities have now been mitigated, in part, by the work of the Estuary Program and its many partners, through improved grazing and farming practices, floodplain restoration, and remediation of mines that are no longer used. Significant portions of the watershed are now preserved through conservation easements or publicly owned open space.

The National Estuary Program and the CCMP

In the 1980s, concerned citizens and public officials organized a conference on the changing conditions of the bay to raise public awareness of threats to the ecosystem's health. By the 1990s, citizens that recognized the significance of the estuary and were concerned about its future formed a grassroots coalition. The efforts of this coalition led to Morro Bay being designated California's first State Estuary. Shortly thereafter, Morro Bay was accepted into the National Estuary Program with approval from the U.S. Congress. A number of studies were commissioned to determine environmental conditions in the bay and watershed. Hundreds of citizen volunteers, along with staff from federal, state and local agencies, developed "action plans" to address the highest priority problems defined by these studies and other scientific work.

What is the NEP?

The National Estuary Program (NEP) was established in 1987 by amendments to the Clean Water Act, with the intent to protect and restore nationally significant estuaries. The program focuses on not only water quality but also on the integrity of the entire estuarine system, including its physical, biological, economic and recreational values.

The Morro Bay National Estuary Program is one of 28 NEPs working to safeguard and improve the health of some of nation's most important coastal waters.

In 2001, after several years of intensive study and public participation, the first Comprehensive Conservation and Management Plan (CCMP) was completed and approved by both the U.S. Environmental Protection Agency (USEPA) and the Governor of California.[1] The primary purpose of the CCMP is to identify problems that threaten the ecological and economic resources of the estuary and watershed, and to define various action plans to effectively reduce those problems. The original CCMP included 61 action plans that the Estuary Program and its partners could implement to begin to address the threats to the estuary. By 2010, all the action plans had been initiated. Most of them are now ongoing in some form; some were limited enough in scope to be fully completed, and a few were found to be ineffective and discontinued.

Organizational Structure of the Morro Bay National Estuary Program

The Estuary Program is a collaborative organization that facilitates cooperative efforts to the benefit the health of the estuary and watershed. Although the Estuary Program, receives part of its funding from the USEPA, it is non-governmental and has no regulatory powers.

The Estuary Program is managed by stakeholder committees. An Executive Committee (EC) makes general policy decisions and evaluates progress. The EC includes representatives from the USEPA, local and state agencies, and representatives of the agricultural, commercial fishing, tourism/recreation, and environmental communities.

The EC is advised by an Implementation Committee (IC) that includes representatives of dozens of agencies and community organizations. The IC also provides a forum for information exchange among groups engaged in conservation work in and around the estuary. The Estuary Program convenes additional working groups for technical advice on education/outreach and science/technical projects.

The Bay Foundation of Morro Bay is a non-profit corporation that employs Estuary Program staff, manages funding and provides administrative oversight.

[1] Morro Bay National Estuary Program. 2001. Comprehensive Conservation and Management Plan. Morro Bay, CA. Accessed at: http://www.mbnep.org/Library/ccmp.html

2012 CCMP Update

Although noteworthy progress has been made in addressing the priority issues highlighted in the 2001 CCMP, they are still largely relevant today. Over the last decade, the understanding of some of these issues has through experience in the field, new research, and environmental monitoring, much of which has been supported by the Estuary Program and its partners. Improved approaches to addressing the priority issues and areas warranting further study have been identified. In addition, new issues not recognized in the first CCMP, notably the effects of climate change, need attention. These developments catalyzed the effort to update the CCMP and its action plans.

In the spring of 2011, the Estuary Program held a public workshop to review the status of the original action plans and to solicit ideas about priority issues currently facing the bay and watershed. During the following summer, four technical working groups of scientific experts and local resource managers met to provide input on some challenging topics: the status of storm water management in the watershed, climate change impacts and adaptations, the management of freshwater resources, and environmental monitoring. All working group meetings were open to the public.

Using public input and the technical advice from the working groups, Estuary Program staff drafted a new framework for the CCMP and an updated list of action plans to direct the continuing efforts of the Estuary Program and its partners. In September 2011, another public workshop was held to present the draft action plans and solicit public comments. Over the subsequent few months, the draft action plans were revised and a draft document was completed.

The draft CCMP became available for public review and comment in March 2012; a public meeting to present the draft is scheduled for March 6th, 2012. Review by the Implementation Committee and adoption by the Executive Committee is expected in summer 2012, with a final document released in the fall.

The updated CCMP will continue to guide the Estuary Program's efforts to address the priority issues facing the estuary, working toward a healthy and productive environment.

Watershed Goals

Codifying strong, visionary goals for the CCMP will help the Estuary Program and its partners maintain focus on the long-term outcomes desired for the Morro Bay estuary and watershed. The goals listed below are written to articulate a long-term vision for the four main areas of the Estuary Program.

1. Water Quality Protection and Enhancement – Water quality in the Morro Bay watershed and estuary supports diverse habitats and wildlife populations, recreation, clean drinking water, and well-balanced economic uses.

   One of the main tenets of the National Estuary Program (NEP) is to protect and restore water quality, as the NEP is part of the federal Clean Water Act. This goal illustrates the aspiration for clean water that supports a variety of uses by people and wildlife in Morro Bay.

2. Ecosystem Restoration and Conservation – The Morro Bay watershed and estuary sustain a resilient community with high habitat connectivity, ample biological integrity, proper ecosystem function, and a vibrant economy.

   This goal illustrates the Estuary Program's interest in conserving and restoring habitats, biodiversity, and ecosystem processes, all of which affect the local economy. The goal also envisions a healthy ecosystem and economy even in the face of change.

3. Public Education, Outreach, and Stewardship – Citizens and visitors around Morro Bay understand basic estuary science and the impacts of specific actions on estuary health, and are engaged stewards

of the Morro Bay estuary and watershed.

This goal represents the importance of informed and engaged citizens for the future health of Morro Bay and a vision that community members will increasingly become stewards of the estuary.

4. Fostering Collaboration – Local citizens, local government, non-profits, state and federal agencies, and public and private landowners collaborate and leverage resources to facilitate effective management and increased scientific knowledge of the Morro Bay estuary and watershed.

   Another core tenet of the NEP is collaboration, as described in the Clean Water Act. This goal showcases the Estuary Program's commitment to fostering collaboration to effectively understand & manage the resources of Morro Bay.

Chapter 2 Priority Issues

The first CCMP approved in 2001 identified seven priority issues facing the estuary:

- Accelerated sedimentation
- Bacterial contamination
- Elevated nutrient levels
- Toxic pollutants
- Scarce freshwater resources
- Habitat loss
- Declining steelhead populations

These topics were considered to be the most pressing issues facing the estuary and its future health at the time the first CCMP was written. All of these issues are still relevant and continue to be high priorities for the Estuary Program, although a wealth of new information has improved the shared knowledge of how these issues impact the estuary and watershed. This new information has been critical in updating the Estuary Program's approach to addressing each of these issues, as evidenced by the updated action plans in Chapter 3. A greater understanding of these environmental issues has also led to the integration of two priority issues into one. After a decade of monitoring, restoration, and outreach efforts, the close connection between habitat loss and the loss of critical species has been clearly demonstrated in the Morro Bay watershed. Considering this close connection and the overlapping methods that are used to address both issues, habitat loss and declining steelhead populations have been integrated into one issue – preserving biodiversity to maintain habitat and ecosystem functions. This new priority issue will allow a broader, more ecosystem-based approach to addressing the important problems of loss of habitat and critical species, including steelhead.

The 2001 CCMP recognized that the estuary and watershed are critical to several activities that are highly dependent on local natural resources, such as oyster farming, commercial fishing, recreation and tourism, farming, and ranching. The updated CCMP more explicitly addresses the inherent issue of balancing important economic and social uses with the needs of the ecosystem. One section of the updated action plans focuses on how estuary-dependent uses can be undertaken in more environmentally sustainable ways.

Considering these updates, the seven priority issues that this CCMP will address are

- Accelerated sedimentation
- Bacterial contamination
- Elevated nutrient levels
- Toxic pollutants
- Scarce freshwater resources
- Preserving biodiversity
- Environmentally balanced uses

Each of the priority issues is discussed further below. Additional background information can be found in the 2001 CCMP document.[2]

Sedimentation

The accumulation of sediment in estuaries is a natural process that generally occurs over thousands of years and may eventually result in the filling in of the estuary. Sources of sediment to the Morro Bay estuary include: creeks draining the watershed; stormwater runoff over land; ocean currents carrying sand through the harbor entrance; and prevailing winds and ocean currents altering the morphology of the sand spit. In Morro

[2] Morro Bay National Estuary Program. 2001. Comprehensive Conservation and Management Plan. Morro Bay, CA. Accessed at: http://www.mbnep.org/Library/ccmp.html

Bay, these natural processes have been accelerated by activities in the watershed that contribute additional sediment to the flow entering the estuary from creeks and stormwater runoff.

At the time of the 2001 CCMP, local studies and modeling efforts indicated that estimated rates of accelerated sedimentation would cause the estuary to fill in within a few hundred years.[3] Other observed changes, including rise of the bottom of Chorro Creek at South Bay Boulevard and the increase in salt marsh habitat at the confluence of Chorro and Los Osos creeks, provided additional evidence for accelerated sedimentation. Since the completion of these studies and the 2001 CCMP, a more nuanced and complex picture of sedimentation has emerged. It is now understood that the majority of sedimentation occurs during episodic storm events. The impact of these events varies greatly depending on the storm intensity and how saturated the ground is prior to any particular storm. Annual rates of sediment accretion observed in the bay, although difficult to quantify over short time frames, appear to be relatively low. However, catastrophic storm events can contribute vast amounts of sediment to the bay in a very short period of time. This new knowledge is based in part on an ongoing effort by the Estuary Program to track the rate of sediment accretion at various locations in the bay. This data set, ongoing since 2004, shows a variable rate of accretion throughout the bay. Locations in the southern most portion of the bay, near Shark's Inlet, and areas of the salt marsh just south of the Morro Bay State Park marina, show greater accretion rates than other areas.[4] Another monitoring effort uses suspended sediment concentrations in creek flow to model sediment loads delivered to the bay. Since this project began in 2008, the results have demonstrated the immense variability in sediment load from year to year.[5] This variability is mainly due to fluctuations in the frequency and intensity of storm events.

Sediment contributions from creeks and stormwater runoff, through the process of erosion, are a natural occurrence. However, a variety of land uses can exacerbate erosion. Urban development increases the amount of impervious surfaces in the watershed, reducing the ability of the ground to absorb rainfall and increasing storm water volumes and velocities. Certain grazing and cultivation practices can reduce or eliminate ground cover, making hillsides and fields more vulnerable to soil loss. An especially significant issue has been wildfires, which leave barren hillsides prone to erosion when storm events occur. In the mid-1990s, the combination of a wildfire that scorched a significant portion of the upper watershed and intensive El Nino rainstorms the following winter resulted in a tremendous amount of sediment flowing to the bay, with significant impacts on eelgrass beds, oyster farms and the bay's form and volume.[6] Alterations in the natural landscape and the spread of non-native vegetation can increase the intensity of wildfires.

In addition to inputs from creeks and stormwater runoff, ocean currents also add sediment to the estuary, primarily at the harbor mouth and in the main navigation channel. For this reason, the harbor entrance is maintained with regular dredging to ensure safety of navigation. Sand from the sand spit is a source of sediment not well understood. Considering this source is a natural process, the management issue of concern is to minimize erosion on the sand spit from plant removal and human use while maintaining healthy native habitats on the spit.

Due to the conditions described, Morro Bay, Los Osos and Chorro creeks are listed as impaired waters under the federal Clean Water Act Section 303(d) for sediment and the Water Board has established total maximum daily loads (TMDLs). (See Chapter 3, action plan MON-1 for further detail on TMDLs.) Estimates of the relative contributions of the two major sub-watersheds suggest that about 80 percent of the stream-borne sediment comes from the Chorro Valley.[7]

Impacts on Beneficial Uses: Sedimentation affects the habitat value of the estuary. As the bay fills, rare coastal wetlands are lost to terrestrial habitats. Shallow water results in increased temperatures and reduces

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[3] Tetra Tech, Inc. 1998. Morro Bay Sediment Loading Study. Morro Bay, CA. Can be accessed at the Estuary Program offices.

[4] Morro Bay National Estuary Program. 2011. Morro Bay Sediment Loading Update. Morro Bay, CA. 48 pp. Accessed at: http://www.mbnep.org/Library/Files/DataSummaries/2011%20Sediment%20Report%20FINAL.pdf

[5] Ibid.

[6] Morro Bay National Estuary Program. 2001. Comprehensive Conservation and Management Plan. Morro Bay, CA. Accessed at: http://www.mbnep.org/Library/ccmp.html

[7] Tetra Tech, Inc. 1998. Morro Bay Sediment Loading Study. Morro Bay, CA.

circulation, adversely affecting water quality and habitat richness. Sediment can impact eelgrass through depth changes, reduction of light penetration, and direct siltation of top of eelgrass. Sediment also degrades habitat for freshwater species, including the red-legged frog and southwestern pond turtle.

The potential loss of bay volume affects commercial and recreational boating navigation. The main channels must be dredged regularly due to sediment accumulation. The State Park Marina has become inaccessible during low tides in the past.

Reduced open water area could also affect the recreational values of the bay, limiting such activities as fishing and boating. Reduction in the estuary's recreational potential may adversely affect bay-related tourism. Sediment can also interfere with the commercial cultivation of oysters.

Upstream from the bay, erosion adversely impacts agricultural land by reducing acreage suitable for cultivation and through the loss of topsoil essential to intensive farming. In streams, silt reduces the quality of spawning habitat for steelhead and can impede steelhead migration during high flow events. Biodiversity and general habitat quality can also be reduced by excessive sediment.

Actions and Trends: Much effort has been directed to addressing the problem of sedimentation.

One approach often discussed would be to dredge the bay or to alter the channels to facilitate improved tidal flushing. The MBNEP and the U.S. Army Corps of Engineers (ACOE) conducted a large-scale analysis of these in-bay solutions, including assessing the possibility of opening the sand spit to the ocean or restoring the bay's natural communication with the sea near Morro Rock[8]. Another specific option was to re-route the mouth of Chorro Creek that had shifted southward in the 1990s from its previous course nearer to the State Park Marina. All of these options were deemed infeasible due their extremely high cost, significant environmental impacts, regulatory impediments, and other concerns.

The Estuary Program and is partners concluded that the most feasible ways to address sedimentation were through reduced erosion in the watershed and by capturing sediment upstream of the bay through various methods, including the restoration of floodplains. A variety of best management practices and restoration techniques can be implemented to reduce erosion. These approaches have been the focus of the Estuary Program and its partners. The Coastal San Luis Resource Conservation District (CSLRCD) spearheaded "Project Clearwater", funded in large part through the Estuary Program, which improved land management practices on private farms and ranches to reduce erosion. The CSLRCD estimated that these efforts prevented thousands of tons of sediment from reaching the bay.[9] Examples of other projects have been undertaken during the last 10 years include: riparian corridor restoration along Walters and Chumash creeks; over 11 miles of riparian fencing to reduce erosion from grazing animals impacting creeks; riparian re-vegetation; remediation of mines that are out of commission; and rural road improvement projects. (See Best Management Practices and Ecosystem Conservation and Restoration Riparian sections in Chapter 3 for further details on these methods.)

Another important project was the Chorro Flats Enhancement Project that opened levees along Chorro Creek, allowing the stream to access its natural floodplain. The CSLRCD estimates that approximately 198,000 cubic yards of sediment had been captured by this project as of January 2001, with the site expected to reach its capacity 35 years from that time[10]. Another floodplain restoration project is managed by the CSLRCD on Los Osos Creek.

New Issues and Perspectives: The experiences of the last 10 years have suggested several important considerations as the program moves forward on addressing sedimentation.

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[8] U.S. Army Corps of Engineers. 2007. Morro Bay Estuary Ecosystem Restoration – Draft Feasibility Report (F4). Morro Bay, CA. 138 pp.

[9] Coastal San Luis Resource Conservation District. 2009. Morro Bay Project Clearwater Final Report. Morro Bay, CA. 122 pp. Accessible at the Estuary Program offices.

[10] Coastal San Luis Resource Conservation District. 2002. Chorro Flats Enhancement Project – Final Report to the California State Coastal Conservancy. 48 pp. Accessed at: http://www.coastalrcd.org/images/cms/files/Chorro%20Flats%20final%20report%20smaller.pdf

With an improved understanding about the nature of sediment sources, the Estuary Program recognizes the need to better understand how the intensity and timing of severe storm events influences the transport of sediment, especially in light of predicted changes in precipitation patterns due to climate change. Determining what transported sediment does once it reaches the bay requires a better understanding of the hydrodynamics and bathymetry of the bay. More specific knowledge about how sediment moves through the watershed and estuary can inform what best management practices and restoration projects are implemented. An important step in implementing projects is evaluating the effectiveness of the approach used. This is an area that the Estuary Program will continue to refine its expertise to bring about the strongest and longest lasting results possible.

Bacteria and Pathogens

In Morro Bay, elevated levels of bacteria in the water present potential health threats to those who utilize the bay for recreational purposes and economic threats to those who depend upon the resources of the bay for their livelihood. Elevated concentrations of bacteria can also adversely affect marine mammals that inhabit the estuary. The Morro Bay estuary, Chorro Creek, Los Osos Creek, Dairy Creek, and Warden Creek are listed as impaired water bodies under the federal Clean Water Act, Section 303(d) for pathogens and have approved TMDLs from the Water Board.

Contributors to bacteria levels in Morro Bay include both point and non-points sources: urban runoff, runoff from rangeland and grazing operations, inadequate waste disposal from boats in the bay, domestic and wild animal waste, and failing or overloaded septic systems.[11] When in compliance with existing permits, wastewater treatment plants do not appear to contribute to elevated bacteria levels. A study of *E. coli* strains in particular indicated that four sources contribute the majority of this particular bacteria type: birds (22%), humans (17%), bovine (14%) and dogs (9%).[12]

Bacteria levels originating from urban runoff, grazing operations and domestic animals enter the creeks and bay primarily during storm events. The amount of bacteria actually transported to waterways may vary based on the intensity and frequency of precipitation. Bacteria contributions also vary by sub-watershed, with Chorro Creek generally contributing significantly more bacteria than Los Osos Creek. Chorro Creek averages higher flows and drains more of the watershed than Los Osos does.

Impacts on Beneficial Uses: In Morro Bay, oysters have been harvested since the 1930s and 1940s. The first oyster lease was established in 1932, and there now exist two active aquaculture operations in the bay. Oysters are filter feeders and thus bacteria and other pathogens in the water can be temporarily concentrated in the shellfish, making them unsafe to eat. While the bay's water is generally clean enough to support commercial oyster farms, certain parts of the bay are currently closed to harvesting and in other areas harvesting may be suspended if bacteria levels become elevated.

Recreation and tourism play a large part in this area's economy and water sports are increasingly popular. Water safe for swimming and human contact is critical to the enjoyment of the bay. Water is tested regularly in the bay and creeks for the presence of *E. coli*, which is an indicator of contamination. After rainstorms, the water in the bay may becomes unsafe for human contact. Most popular recreational sites generally test at levels safe for swimming; however, sites in the southern portion of the bay around Los Osos and Baywood

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[11] Central Coast Regional Water Quality Control Board. 2002. Support Document for Morro Bay Total Maximum Daily Load – For Pathogens (Including Chorro and Los Osos Creeks). San Luis Obispo, CA. 54 pp. Accessed at: http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/morro/pathogen/morrobay_path_tmdl_projreport.pdf

[12] Kitts, C., Moline, M., Schaffner, A., Samadpour, M., McNeil, K., and S. Duffield. 2002. Identifying the Sources of *Escherichia coli* Contamination to Shellfish Growing Areas of the Morro Bay Estuary. San Luis Obispo, CA. 36 pp. Accessed at: http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/morro/pathogen/mb_dna_final_report.pdf

Parks may exceed recommended bacteria levels in as many as 20 percent of samples taken.[13] Bacteria levels in the creeks tend to exceed standards at even higher rates than in the bay itself.

Elevated bacteria and pathogen levels can also adversely impact marine mammals that inhabit the estuary, such as sea otters and sea lions.

Actions and Trends: Several programs and major projects have been completed to address pathogenic pollution. One approach is the upgrade and installation of wastewater treatment plants. The California Men's Colony (CMC) treatment plant was upgraded in 2007 to tertiary treatment and is planning an additional upgrade to address chlorine in its discharged effluent (see BMP-11). The septic systems of Los Osos and Baywood Park are being largely replaced by a new wastewater treatment plant scheduled to be completed in 2014 (see BMP-10).

A number of best management practices and projects have been implemented throughout the watershed, in partnership with public and private landowners, to reduce bacteria concentrations in stormwater runoff. These practices include riparian fencing, installation of off-creek water sources for grazing operations, and pasture management (such as rotational grazing). Over 11 miles of stream have been protected with riparian fencing. Education and outreach about disposal of pet waste and the installation of Mutt Mitt dog waste bag dispensers have also helped reduce bacterial contamination. Over 200,000 Mutt Mitt bags are distributed each year in the watershed.

Other outreach efforts have focused on educating the boating community about proper waste disposal and use of pump-out facilities and the removing illegal moorings and abandoned vessels. These projects have been undertaken in partnership with California Department of Fish and Game (DFG), State Parks, and the City of Morro Bay Harbor Department.

New Issues and Perspectives: Future efforts to address elevated bacteria levels will continue the implementation of effective best management practices, such as the ones described above and explored in further detail in the Best Management Practices section of Chapter 3. In addition, project effectiveness monitoring will continue to be improved to demonstrate the capacity of particular approaches to bring about desired changes. Effectiveness monitoring is needed not just on a project-by-project basis, but also on a cumulative basis over many projects.

The Estuary Program recognizes the need to better understand how the bay's bathymetry and hydrodynamics influence the movement and residence time of bacterial pollution. How the bathymetry of the bay and inputs of freshwater from the watershed influence tidal flushing and bacteria concentrations is not well understood.

In general, a more complete understanding of how pathogens move through the ecosystem is needed. Other bacterial pathogens, such as *taxoplasma*, have been shown to detrimentally affect marine life. Other types of pathogens may also be affecting marine and riparian organisms and may need further study to determine sources and solutions.

Nutrients

Nutrient enrichment, primarily from nitrates, can have detrimental environmental effects for the bay and the watershed. Excess nutrients increase the growth of algae blooms. Algae take up oxygen when they are not photosynthesizing and can consume large amounts of oxygen dissolved in the water column. Dissolved oxygen (DO) is also reduced when algae blooms die off and decompose. Thus, high nutrient levels and low

[13] Morro Bay National Estuary Program. 2010. Estuary Tidings. Morro Bay, CA. 13 pp. Accessed at: http://www.mbnep.org/Library/Files/Tidings/Tidings.pdf

DO are usually linked. Appropriate levels of DO are critical to supporting aquatic life such as fish and invertebrates. Objective for DO concentrations are outlined in the Water Board's Basin Plan.[14]

Algae blooms and low levels of DO have been regularly observed in Morro Bay, especially in the southern portion of the bay during dry seasons of summer and fall. Elevated levels of nutrients, along with warmer water temperature and poor circulation conditions, contribute to this problem. Chorro Creek, Los Osos Creek, Warden Creek, and Warden Lake are all listed as impaired waters for nutrients and dissolved oxygen under Section 303(d) of the Clean Water Act and are subject to TMDLs adopted by the Water Board. Dairy Creek (a tributary of Chorro Creek) is also listed for dissolved oxygen and has an approved TMDL.

Contributors to elevated nutrient levels in the Morro Bay area include wastewater treatment effluent from CMC, cropland runoff, rangeland runoff and natural background concentrations from biological activity.[15,16] Nutrients in runoff can come from fertilizers, animal waste, and heightened water temperatures due to a lack of shading. When creeks do not have adequate vegetative cover, surface water temperatures increase and reduce circulation. Adequate circulation helps maintain high level of DO.

Impacts on Beneficial Uses: When excessive nutrients lead to algae growth, the water column is robbed of DO essential to many fish and invertebrates. Thus, nutrients can damage the habitat value of the creeks and bay, threatening the ability of the estuary to function as a nursery for fish and to sustain productive commercial oyster beds. High nutrients and low DO also reduce insects and other macro-invertebrates that live in the creeks that are essential food sources for steelhead and many other species. In extreme cases, low DO can promote fish kills.

Elevated nitrate levels also impair water for municipal and domestic water supplies, including drinking water. Chorro Creek, with some of its tributaries, is the most heavily used of the impaired waterbodies in the watershed for municipal and domestic water supply.

Actions and Trends: To address elevated nutrients in the effluent discharge from CMC wastewater treatment, the plan was upgraded in 2007 to full tertiary treatment (see BMP-11). Under normal operating conditions, the plan now meets its permit requirements for levels of nitrate in its effluent.

Other actions have focused on addressing nitrates in stormwater runoff. MBNEP and its partners have undertaken programs to encourage proper use of fertilizers at both the commercial farming and household levels. Other educational programs encourage residents to keep pollutants from entering the storm drains.

Projects to increase riparian vegetation along Chorro Creek and its tributaries are aimed at increasing water circulation and dissolved oxygen. These projects include riparian fencing, re-vegetation of riparian corridors, and restoration of highly impacted stream sites. Descriptions of these approaches are presented in the riparian section of the Ecosystem Conservation and Restoration section of Chapter 3.

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[14] Central Coast Regional Water Quality Control Board. 2011. Water Quality Control Plan for the Central Coast Basin. San Luis Obispo, CA. 223 pp. Accessed at: http://www.swrcb.ca.gov/rwqcb3/publications_forms/publications/basin_plan/docs/basin_plan_2011.pdf

[15] Central Coast Regional Water Quality Control Board. 2007. Total Maximum Daily Load for Nutrients and Dissolved Oxygen in Chorro Creek. San Luis Obispo County, CA. 47 pp. Accessed at: http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/chorro_creek/chorro_nut_proj_rpt.pdf

[16] Central Coast Regional Water Quality Control Board. 2005. Total Maximum Daily Load for Nutrients in Los Osos Creek, Warden Creek, and Warden Lake Wetland. San Luis Obispo County, CA. 47 pp. Accessed at: http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/los_osos_creek/los_osos_nutr_tmdl_proj_report.pdf

New Issues and Perspectives: MBNEP and its partners will continue efforts to address nitrate concentration in stormwater runoff and work toward continued improvement in riparian vegetation and canopy cover throughout the watershed.

Toxic Pollutants

Toxic pollutants include pesticides, organic compounds, heavy metals, and a variety of chemical compounds. The upper Chorro Creek watershed was historically mined for chromium and nickel, naturally occurring metals that can be toxic in high concentrations. When the 2001 CCMP was approved, Chorro Creek was listed as impaired due to heavy metals under Section 303(d) of the Clean Water Act. Subsequent analysis, however, showed that observed levels of these elements in the creek water and sediments did not pose a threat to people or wildlife and Chorro Creek was de-listed.

Other non-natural sources of toxics continue to impact water quality and wildlife in the bay and watershed. Toxics enter the bay and creeks primarily through non-point source pollution from stormwater runoff. Uses that contribute toxics include household and agricultural pesticides, detergents and soaps, oils and lubricants from street drainage, and household or commercial cleaning products. Other potential sources are non-fouling paints and other chemicals used for boat maintenance, as well as fuel spills and illegal dumping. Recent studies have also raised concerns about emerging contaminants, which are toxics not regulated with regard to water quality and have environmental impacts that are not well understood. Such contaminants represent a growing area of water quality research that may provide insights and new perspectives in the future.

Toxic pollutants can accumulate in sediments and cause future environmental issues when sediments are disturbed and the compounds are released into the water column. The extent of this issue in Morro Bay is not well understood. Another possible environmental impact of toxics is bioaccumulation – when chemicals accumulate in the tissues of organisms at higher concentrations than what is found in the water column or sediments.

Impacts on Beneficial Uses: Both contact and non-contact water recreation can be adversely affected by concentrations of these pollutants due to potential impacts on human health. Marine wildlife, shellfish harvesting, fish migration, spawning habitat, and rare, threatened, and endangered species habitat can all be damaged by toxic pollutants. Certain aquatic organisms are acutely affected even by very low concentrations of toxic pollutants.

Actions and Trends: The California Department of Public Health (DPH) does not currently test for toxics and heavy metals in shellfish. Results in prior years from the NOAA and state Mussel Watch programs indicated that metal and toxic concentrations are not present in Morro Bay's shellfish populations at levels that would be of concern for environmental and human health.[17] Further study is needed to determine the current status of toxics and heavy metals in both the sediment and shellfish populations of Morro Bay. Limited research results have documented the possibility of elevated heavy metal concentrations in sediment in Morro Bay.[18]

State law and County regulations closely control the application of agricultural pesticides. Municipalities and other dischargers of stormwater and wastewater must comply with NPDES (National Pollutant Discharge Elimination System) permits from the Water Board. Construction projects require a Stormwater Pollution Prevention Plan (SWPPP) detailing how stormwater runoff will be minimized and monitored. The Estuary Program has shared data and technical knowledge to support local partners in meeting NPDES and SWPPP requirements.

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[17] National Oceanic and Atmospheric Administration's Mussel Watch Program Data Portal: http://ccma.nos.noaa.gov/about/coast/nsandt/download.aspx

[18] Pehaim, J. 2004. Heavy Metals in Clams and Sediments from Morro Bay. Master's Thesis, California Polytechnic University, San Luis Obispo, CA. 57 pp. Accessed at: http://ceenve3.civeng.calpoly.edu/nelson/THESES/Jennifer%20Pehaim%202004.pdf

Efforts to reduce toxic pollutants from urban runoff and the boating community have centered on education and outreach projects. The Estuary Program has disseminated information about proper use and disposal of toxic materials. The City of Morro Bay has also installed additional hazardous waste disposal facilities for boaters.

The Estuary Program, City of Morro Bay Harbor Department, State Parks, and DFG have completed a number of cooperative efforts to remove illegal moorings and abandoned vessels in the bay. These efforts reduced potential pollution sources and also provided aesthetic and safety benefits.

New Issues and Perspectives: The Estuary Program and its partners will continue work to educate the local community about proper use and disposal of hazardous materials. Stricter regulations regarding stormwater management at the municipal level are being implemented by state and federal agencies.

Facilities are needed for boat owners to conduct repairs and maintenance while minimizing pollution to the bay. The Estuary Program supports the city of Morro Bay in its efforts to make such facilities available. Emerging contaminants are likely to be a growing issue in the future, as the scientific and regulatory communities gain greater understanding of their sources and effects. The Estuary Program will continue its involvement in efforts to better understand emerging contaminants and learn about ways to reduce their effects.

Competition for Freshwater Resources

Freshwater is critical to the health of the estuary. Estuarine habitats such as saltwater marshes require regular inflows of freshwater to function properly. Creeks must have adequate flows to provide habitat for a variety of water-dependent plants and animals and to accommodate steelhead passage. Freshwater is also critical for the wide variety of land uses in the watershed, including farming, ranching, and urban communities. Competition among domestic, agricultural, and environmental uses for scare freshwater resources is a priority issue in the Morro Bay watershed.

The watershed's Mediterranean climate and variable precipitation patterns (both seasonally and from year to year) limit the amount of freshwater that enters the system. Creek flow naturally diminishes in the summer and autumn due to low rainfall during these times and shallow wells drawn for agriculture and domestic use can directly affect creek flow (particularly in the Chorro Creek watershed). Parts of Chorro Creek are fully appropriated (as regulated by the State Water Board), indicating strong competition for scarce freshwater resources in this area. Groundwater resources are also impacted in the watershed. The Los Osos upper aquifer is impacted by nitrates and the lower aquifer is exhibiting signs of saltwater intrusion. Morro Bay's municipal groundwater wells are also contaminated with nitrates. More information on freshwater resource uses in the Morro Bay watershed is presented in the Freshwater Flow section of Chapter 3.

Additional freshwater is contributed to the system from treated effluent discharged to Chorro Creek from the CMC wastewater treatment plant. CMC is required to discharge a minimum continuous flow of 0.75 cfs (cubc feet per second) for the benefit of aquatic resources, such as steelhead.

Impacts on Beneficial Uses: Reductions to freshwater flows in the watershed have a direct impact on a wide variety of beneficial uses. As noted above, freshwater is a critical element of several rare habitat types. In addition, reduced flows can impede the migration and spawning of steelhead; low flows that contribute to higher water temperatures can directly affect the viability of steelhead. Freshwater is essential to other special status species found in the watershed, including the red-legged frog and southwestern pond turtle.

Groundwater provides domestic water to users throughout the watershed, but it is especially essential to Los Osos and Baywood as a sole source of drinking water. The City of Morro Bay also uses wells in the lower Chorro Valley when its primary source, imported state water, is unavailable. In both watersheds, groundwater is used for crop irrigation and to provide water for cattle.

Actions and Trends: The State Water Board regulates surface water rights and issues permits for allowable withdrawals in the watershed. The groundwater basins in the watershed have been extensively studied and the Los Osos groundwater basin is the subject of an Interlocutory Stipulated Judgment (ISJ). The ISJ requires all of the water purveyors in Los Osos to develop a basin management plan to manage withdrawals. As of the writing of this document, the ISJ process is still ongoing. The County Master Water Plan addresses water resource issues in the county and specifies management approaches. The Estuary Program has focused its efforts on encouraging water conservation practices in the watershed with a wide variety of partners and supporting integrated water management approaches.

New Issues and Perspectives: New issues to address with regard to freshwater flow include

- Addressing impacts of climate change to freshwater resources
- Improving water conservation practices
- Increasing infiltration of runoff to groundwater aquifers
- Improving the understanding of freshwater needs for public trust resources

Many new action plans in Chapter 3 capture these issues, particularly FWR-1 through FWR-6, CLIM-1, USE-5, and many of the best management practices (BMP) actions. Additional background information is provided in those sections. Significant efforts have been made in some of these areas already, including water conservation and infiltration of runoff.

Preserving Biodiversity to Maintain Habitat and Ecosystem Functions

Biodiversity is "the variety of life and its processes; and it includes the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur."[19, 20] The rich biodiversity found in the Morro Bay watershed and estuary is critical to the ecosystem's ability to continue providing important functions, such as habitat for critical species, flood protection, and water filtration. Rich biodiversity strengthens the environment's resilience in the face of future change, including altered precipitation patterns and temperature gradients due to climate change. Citizens and scientists alike have expressed concern over species and habitat loss in the watershed over the last twenty years (both recognized as priority issues in the 2001 CCMP), and preserving biodiversity can address both of these concerns. By taking the more holistic approach of emphasizing biodiversity, the Estuary Program anticipates more effective and long-lasting conservation results. The core conservation issues to be addressed in the Morro Bay watershed in order to preserve biodiversity include

- Preventing habitat degradation
- Improving and preserving the ecosystem's ability to be resilient to and adapt to changing conditions
- Protecting and expanding migration corridors
- Maintaining ecological connections between habitats to protect important ecosystem functions

Biodiversity comprises many habitats, species, and ecosystem processes in the Morro Bay watershed – wetlands, marshes, mudflats, eelgrass beds, maritime chaparral, riparian canopies, oak woodlands, 15 federally listed species, many endemic species, and the numerous ecosystem processes that support these habitats, species, and important human uses.

Habitat loss, degradation, and fragmentation all can negatively impact diversity. Most of these causes occur through land uses that alter the natural landscape, such as urban development and agriculture. Invasive species can also decrease biodiversity by outcompeting native species for habitat and resources. Climate change is likely to impact biodiversity and related ecosystem functions, but the exact consequences are difficult to predict. Poor water quality, pollution, and competition for natural resources also affect biodiversity.

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[19] Keystone Center. 1991. "Final Consensus Report of the Keystone Policy Dialogue on Biological Diversity on Federal Lands."

[20] California Biodiversity Council. "Scientific Definitions of Biodiversity." Found at: http://biodiversity.ca.gov/Biodiversity/biodiv_def2.html. Accessed February 17, 2012.

Impacts on Beneficial Uses: Several habitat types that have survived in and around Morro Bay – including brackish wetlands, salt marsh, mud flats, eelgrass beds, coastal dunes complexes and maritime chaparral – are quite rare in southern and central California. They constitute remnants of a natural world that has been lost in more populated and developed areas. Numerous special status species are dependent on these habitats. Healthy habitats are also critical to shellfish farming and to recreational and commercial fishing.

Morro Bay is renowned for its natural beauty, including its abundance of fish, waterfowl and marine mammals. These factors form the base of the local recreation and tourist economy and are at risk when biodiversity is threatened.

Action and Trends: Land use planning and other policy strategies have provided some buffer to increased development pressure on biodiversity in the watershed. The entire estuary and large portions of the watershed fall under the jurisdiction of the California Coastal Commission, and both the City of Morro Bay and County of San Luis Obispo have Local Coastal Plans and other planning regulations that stipulate protections for native habitats and species.

Habitat preservation through land acquisition and conservation easements has also helped protect biodiversity. In many cases, acquisitions resulted in the protection of special habitats or species. In other cases, acquisitions helped to form green belts around the developed communities of Los Osos and Morro Bay to provide clear boundaries between urban growth and open space. Since the adoption of the 2001 CCMP, thousands of acres of land around the bay and in the watershed have been acquired or placed in conservation easements.

In addition to preservation, the Estuary Program and its partners have restored many areas of previously degraded habitat. Several miles of riparian corridors and hundreds of acres of land have been enhanced through these efforts. The implementation of best management practices to improve land stewardship has also supported the conservation of biodiversity (see the Best Management Practices section of Chapter 3 for more information). Work to improve water quality, such as what is described in previous sections of this chapter, benefits biodiversity. Finally, many education and outreach efforts in the watershed have increased awareness of important habitats and species and how to reduce impacts to them when people are recreating or engaging in other uses in the watershed.

New Issues and Perspectives: Ongoing efforts to preserve and restore habitats, promote best management practices, improve water quality, and educate citizens about biodiversity in the watershed will continue. This wide array of activities encompasses nearly all of the action plans outlined in Chapter 3.

Future efforts to preserve biodiversity and ecosystem functions are likely to include more strategic approaches to land acquisition and easements, with a goal of preserving a diverse and robust set of habitats to promote migration of species between habitats and adaptation to climate change. Best management practices will focus on the most effective approaches, as demonstrated by monitoring and evaluation efforts. Future efforts will also include work to limit the impact and spread of invasive species in the watershed, as outlined in the Estuary Program's Invasive Species Action Plan.[21]

Climate change is expected to significantly impact habitats, species, and ecosystem functions. The Estuary Program will work toward helping the watershed's habitats be resilient and adapt to climate change by encourage scientific work to better understand local impacts of climate change. The Estuary Program will also support efforts to develop and implement Climate Action Plans to address climate predictions and adapt to change. Outreach and education will also be a part of the Estuary Program's response to climate change. (See the Climate Change section of Chapter 3 for further details.)

[21] Jon Hall, Morro Bay National Estuary Program. 2010. Morro Bay Invasive Species Action Plan version 11-28-2010. Morro Bay, CA, 28 pp. Found at:
http://www.centralcoastinvasives.com/centralcoastinvasives.com/Action_Plan_files/ISAP%20low%20res.pdf

Environmentally Balanced Uses

Many uses in the watershed and estuary depend on local natural resources – shellfish farming, commercial fishing, energy generation from the Morro Bay Power Plant, farming, ranching, tourism, and water-based recreational activities are just some examples. Although many of these uses were discussed in the 2001 CCMP, the Estuary Program now recognizes the priority issue inherent in the challenge of balancing important economic and social uses with the needs of the ecosystem.

Many important human uses necessarily have some impact on natural resources. Agriculture, ranching, and urban development require changes to the natural landscape and produce stormwater runoff. Water-cooled energy generation impacts aquatic life. Recreational activities in the bay may scare wildlife or impact habitats. All of these uses are also integral to the economy and quality of life people experience in the watershed. The challenge facing the local community is how to balance these uses with the needs of the ecosystem in a manner that preserves those important economic and social qualities.

Impacts on Beneficial Uses: Each of these activities is itself a beneficial use. They can be the cause of impacts to other beneficial uses if they adversely affect important environmental values. Urban development, for example, has occurred on a number of important habitat types, such as coastal dune scrub and marshes. Current development plans and regulations at the state, county, and municipal level now require mitigation of the loss of important habitats. The use of cooling water for energy generation at the power plant can impinge or kill fish larvae and fish fry (young fish at the post-larval stage) and invertebrate larvae. The Coastal Commission, Water Board and California Energy Commission provide permits to the operators of the power plant and require a number of mitigation measures to combat these impacts. More information is provided in Chapter 3, under the action plan USE-4.

Not only can certain uses result in environmental impacts, but they can also impact each other. Stormwater runoff from a variety of land uses can degrade water quality that is essential for shellfish farming operations and recreational activities. Recreational activities such as kayaking and paddleboarding can scare wildlife away that bird watchers enjoy.

New Issues and Perspectives: The Estuary Program's work to address this priority issue will focus on supporting local partners in striking a balance between uses and the needs of the environment. A first step will be to determine the key areas of concern under this priority issue and developing approaches to address those concerns with partners. Action plans that address this priority issue include those presented in the Environmentally Sound Estuarine Resource Use section of Chapter 3.

Chapter 3 Action Plans

The heart of the CCMP is the *action plans* that the Estuary Program will undertake to support the conservation and sound management of the estuary and watershed. These actions were developed through the hard work and dedication of numerous community members and partners over the past fifteen years. Many of newly revised action plans are deeply rooted in the first CCMP; others address new issues and approaches that have risen over the past decade.

The action plans are now organized by categories of similar actions, rather than by priority issue. This new approach is the basis for an entirely new framework for the action plans, which is illustrated in Figure 1 and detailed in Table 1. Now each action plan clearly addresses multiple priority issues, something which was difficult to track in the first version of the CCMP. Leveraging each action for the greatest impact will allow the Estuary Program and its partners to effect greater change in a more strategic fashion. The new categories of action plans are: Land Acquisition, Water Quality Standards and Monitoring, Best Management Practices, Ecosystem Conservation and Restoration, Watershed Crew, Freshwater Resources, Climate Change, Environmentally Sound Estuarine Resource Use, and Education and Outreach. Each section of this chapter summarizes issues and approaches encompassed by these categories.

Each action plan includes a short discussion followed by a list of potential partners, timeframe, cost estimates, and ways that the implementation of the action plan can be tracked. The priority issues address by each action plan are shown in Table 1.

Partners refers to those public agencies, non-profit groups, or other organizations that will likely be involved in the implementation of the action plan due to the nature of the work involved and the mission and goals of each partner organization. Listing in the partners section does not commit any organization or individual to any specific activity; rather, it is recognition of that entity's previous work and engagement relevant to the action plan in the watershed and an expectation of continued interest and involvement.

Timeframe refers to when important milestones are expected to be reached. At this stage of the program, many of the action plans have been initiated and their implementation is simply ongoing. In most cases, the timing of specific projects is contingent on a number of factors, particularly funding availability.

Cost refers to the estimated funding needed to implement the action plan. A simple code is used to signify the total cost of the action plan, or in the case of ongoing ones, the typical annual cost:

$	$25,000 or less
$$	$25,000 - $100,000
$$$	$100,000 - $500,000
$$$$	More than $500,000

In many cases, different elements of an action plan may have widely disparate costs; for those action plans, a short note on the range of likely costs is included. The Estuary Program is also aware that cost estimates, even ones as broad as are shown, are likely to change over time as cost categories fluctuate and new approaches are realized.

Implementation tracking refers to how the program, partners, and the public can determine whether or not an action plan has been implemented and how the progress of implementation may be measured. Many of the measures presented are general in nature, recognizing that more specific measures will be developed for individual activities and projects under each action plan.

Note: Performance measures will also be developed to track change in the condition of each priority issue. The Estuary Program is working on developing these performance measures and will include them in the final CCMP document.

The Estuary Program recognizes that in a complex and interrelated system such as the Morro Bay watershed, many actions will relate to or complement other actions. Thus, there are frequent cross references among the action plans to help highlight some of these important interconnections.

This updated CCMP is strongly rooted in the first CCMP, which proved so successful in guiding the Estuary Program's first decade of work. Most of the new action plans are updates or refinements to earlier ones; modifications to an action plan may reflect new conditions, a better understanding of underlying issues, more current technology or data, or simply a change in the status of a successful action plan from its initiation stage to ongoing implementation.

Where new action plans are closely linked to earlier ones, the former action plans are referenced. The first version of the CCMP, as well as a list of the action plans in that version, can be found in the Library section of the Estuary Program's website or by visiting the Estuary Program offices.[22]

One critical issue impacting the Morro Bay estuary and watershed today, which was not addressed in the first CCMP, is climate change. The causes and impacts of climate change are complex and difficult to predict. A specific category of action plans addresses this issue and aims to increase the understanding of local impacts from climate change and appropriate actions to address those impacts. However, climate change must also be considered in many of the other action plans because future climate scenarios may impact the outcomes of those actions. Throughout the CCMP, action plans that are likely to be strongly impacted by climate change when they are implemented are marked with a ⦿.

Lastly, although there is a section of action plans specific to education and outreach, many of the other action plans also contain educational elements. To highlight this fact, action plans in which education and outreach are core components are noted with a ★.

Figure 1: *Conceptual framework of the CCMP. Action plans, organized by type of action, address multiple priority issues. Watershed goals guide all of the work of the Estuary Program.*

Watershed Goals

	Priority Issue *A*	Priority Issue *B*	Priority Issue *C*	Priority Issue *D*	Priority Issue *E*
Action Plan *1*	✓			✓	
Action Plan *2*		✓			✓
Action Plan *3*		✓	✓	✓	✓
Action Plan *4*	✓	✓	✓	✓	

[22] The Estuary Program's website (as of August 2012) is www.mbnep.org. The offices are currently located at 601 Embarcadero, Suite 11, Morro Bay CA 93442.

Table 1: *A matrix documenting which priority issues are addressed by each action plan.*

				Bacteria (B)	Nutrients (N)	Toxics (T)	Sediment (S)	Bio-diversity (BIO)	Fresh-water Flows (F)	Balanced Uses (BU)
Categorized Action Plans										
Land Acquisition				B	N	T	S	BIO	F	BU
		LA-1	*Protect Special Habitats/Species*					x		
		LA-2	*Restore Floodplains*				x	x	x	
		LA-3	*Direct Urban Development*	x	x	x	x	x	x	x
		LA-4	*Reduce Water Demand*					x	x	
		LA-5	*Enhance Public Recreation*							x
Water Quality Standards and Monitoring				B	N	T	S	BIO	F	BU
	TMDLs									
		MON-1	*Support Development of TMDLs*	x	x	x	x			x
	Monitoring Approaches									
		MON-2	*Monitor Environmental Indicators*	x	x	x	x	x	x	x
		MON-3	*Monitor Project Effectiveness*	x	x	x	x	x	x	x
	Volunteer Monitoring Program (VMP)									
		MON-4	*Maintain VMP*	x	x	x	x	x	x	x
	Monitoring Partners									
		MON-5	*Support Partners*	x	x	x	x	x	x	x
		MON-6	*Support Research Activities*	x	x	x	x	x	x	x
Best Management Practices				B	N	T	S	BIO	F	BU
	Agricultural and Grazing									
		BMP-1	*Agricultural and Grazing BMPs*	x	x		x	x	x	x
	Rural Lands									
		BMP-2	*Rural Roads Erosion*				x	x		
		BMP-3	*Fire Management Plan*				x	x		
		BMP-4	*Mine Remediation*			x	x	x		
	Urban									
		BMP-5	*Support BMPs by private landowners and municipalities*	x	x	x	x			x
		BMP-6	*Reduce Pet Waste*	x						
		BMP-7	*Support Stormwater BMPs*	x	x	x	x			x

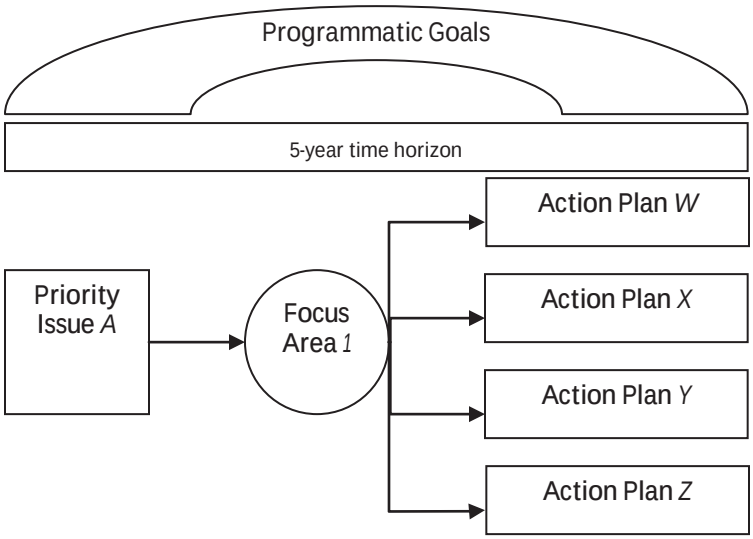
	Boating								
		BMP-8	*Harbor Operations BMPs*	x		x		x		x
		BMP-9	*Boating BMPs*	x		x		x		x
	Municipal Wastewater Plants								
		BMP-10	*Los Osos Wastewater*	x	x					x
		BMP-11	*CMC Wastewater*	x	x			x	x	
		BMP-12	*MB Wastewater*	x	x					
Ecosystem Conservation and Restoration				B	N	T	S	BIO	F	BU
	Riparian								
		ECR-1	*In-stream Habitat*	x	x			x	x	
		ECR-2	*Riparian Corridors*	x	x		x	x	x	
	Wetlands								
		ECR-3	*Wetlands Protection and Enhancement*	x	x			x		x
		ECR-4	*Wetlands Inventory*	x	x			x		x
	Estuarine								
		ECR-5	*Sediment Traps*				x	x		
		ECR-6	*Hydrology and Bathymetry*				x	x	x	
		ECR-7	*Eelgrass Data and Research*					x		x
		ECR-8	*Eelgrass Restoration*					x		x
		ECR-9	*Regional and National Collaboration*	x	x	x	x	x	x	x
		ECR-10	*Nutrient and Bacteria Dynamics*	x	x					
		ECR-11	*Conserve Ecosystem Functions*	x	x	x	x	x		x
	Upland								
		ECR-12	*Upland Habitats*					x		
	Special Status Species and Recovery Plans								
		ECR-13	*Population Dynamics*					x		
		ECR-14	*Support Recovery Plans*					x		
		ECR-15	*Steelhead Barriers and Habitat*					x	x	
	Invasive Species								
		ECR-16	*Invasive Species Action Plan*				x	x	x	x
Watershed Crew				B	N	T	S	BIO	F	BU
		CREW-1	*Watershed Crew*	x	x	x	x	x	x	x
Freshwater Flow				B	N	T	S	BIO	F	BU
	Resource Management								
		FWR-1	*Manage Freshwater Resources*					x	x	x
		FWR-2	*Scientific Information for Management*					x	x	x

		FWR-3	*Understand Flow for Public Trust Resources*					x	x	x
		FWR-4	*Chorro Valley Water Users Group*					x	x	x
	Water Conservation and Re-Use									
		FWR-5	*Water Conservation*					x	x	x
		FWR-6	*Groundwater Re-charge*					x	x	x
Climate Change				B	N	T	S	BIO	F	BU
		CLIM-1	*Climate Change Information*	x	x	x	x	x	x	x
		CLIM-2	*Climate Action Plans*	x	x	x	x	x	x	x
		CLIM-3	*Climate and Adaptation Education*	x	x	x	x	x	x	x
Environmentally Sound Estuarine Resource Use				B	N	T	S	BIO	F	BU
	Recreational Uses									
		USE-1	*Recreational Uses*					x		x
	Shellfish Farming									
		USE-2	*Shellfish Farming*	x				x		x
	Commercial Fishing									
		USE-3	*Commercial Fishing Port Uses*			x				x
	Morro Bay Power Plant									
		USE-4	*Morro Bay Power Plant*					x		x
	Urban Development									
		USE-5	*Urban Development*	x	x	x	x	x	x	x
Education and Outreach				B	N	T	S	BIO	F	BU
	Public Education and Outreach									
		EO-1	*Public Outreach and Education*	x	x	x	x	x	x	x
	State of the Bay									
		EO-2	*State of the Bay*	x	x	x	x	x	x	x
	Nature Center and Related Displays									
		EO-3	*Nature Center*	x	x	x	x	x	x	x
	Formal Education Programs									
		EO-4	*Formal Education Programs*	x	x	x	x	x	x	x

Prioritization

The breadth and depth of the action plans presented in this chapter illuminate the vast amount of work that can be done to conserve, protect, and restore the Morro Bay estuary. The actions outline a universe of possible projects and activities that could not all be accomplished by the Estuary Program in the next five years. Therefore, the Estuary Program has developed an approach to prioritize its work over this time period. A set of focus areas has been chosen for each priority issue. The broad array of action plans will then serve as tools to achieve results in each of those focus areas. When developing the annual workplan, the Estuary Program will specify which actions plans will be implemented to address the focus areas. Many of the focus areas described below encompass broad environmental issues for which a solution may not be feasible in the next five years. Rather than serving as concrete endpoints, these focus areas are designed to direct the Estuary Program's efforts to create some measurable results in addressing the priority issues outlined in Chapter 2. Figure 2 illustrates this prioritization approach.

Figure 2: *As with all of the Estuary Program's work, the four goals described in Chapter 1 overarch all the priority issues and focus areas. Each priority issue has a number of focus areas, described below. For simplification purposes, the chart shows one issue and one focus area. A number of relevant action plans can be used to address each focus area over the 5-year time horizon.*



Sedimentation

Over the next five years, the Estuary Program will focus its efforts to address sedimentation on the following focus areas:

A. Floodplains – Floodplain restoration has been, and will continue to be, a priority for the Estuary Program. Work in this area will include support for partner efforts to restore and enhance floodplains and the implementation of new floodplain restoration projects when feasible.
B. Riparian buffers – Healthy and well-vegetated riparian buffers provide an important barrier to sedimentation by stabilizing creek banks and preventing erosion. The Estuary Program will continue its work to restore and enhance riparian buffer vegetation throughout the watershed.
C. Upland erosion sources – The upper watershed possesses a highly erodible geography and has been recognized as a significant source of sediment to the bay. The Estuary Program will continue its work to address erosion problems in the upper watershed, including improvements to rural roads and fire management, and will also aim to develop a better understanding of relative erosion from individual sub-watersheds. This understanding will help the Estuary Program and its partners prioritize upland implementation projects.

Bacteria

Over the next five years, the Estuary Program will prioritize its efforts to address bacterial contamination by the following focus areas:

A. Disposal of waste in the estuary – One source of bacteria in the estuary is improper disposal of human fecal matter from boats. The Estuary Program in the past has supported efforts to install new pump-out facilities, upgrade old ones, encourage alternative pump-out options, and educate the boating public about proper waste disposal. The Estuary Program will continue these efforts over the next five years.

B. Stormwater management – Non-point source runoff during storm events transmits elevated concentrations of bacteria to the creeks and estuary. To better address this important source, a stronger understanding of the dynamics of stormwater as a mechanism for transporting bacteria is needed. More detailed information in this realm would help the Estuary Program better tailor best management practices and projects to achieve greater improvements in water quality. Over the next five years, the Estuary Program will focus on strengthening this understanding and continuing to implement best management practices and projects to address bacteria sources.

C. Determining bacteria sources in specific areas – Although past efforts have demonstrated general sources of bacteria in the watershed, the Estuary Program has often found it difficult to pinpoint site-level sources when implementing best management practices and restoration projects. This lack of site-level detail can make it difficult to achieve water quality improvements and track project effectiveness. Work in this focus area will be aimed at improving site-level understanding of bacteria sources as applicable.

Nutrients

Over the next five years, the Estuary Program will focus its efforts to address elevated nutrient concentration on the following focus areas:

A. Reducing nutrient loads in Los Osos valley from agricultural sources – Agricultural lands in Los Osos valley contribute nutrient runoff to creeks and the estuary. The Estuary Program has worked collaboratively with farmers and partners (such as CSLRCD and NRCS) to implement projects designed to reduce nutrient inputs to the watershed and monitor results. Future water quality regulations are likely to increase requirements on farmers to address nutrient issues. To address this focus area, the Estuary Program will continue its partnership work on implementation and monitoring and support the agricultural community in future efforts to reduce nutrient pollution.

B. Monitoring efforts to track change in bay water quality – Over the next five years, the Estuary Program will endeavor to better understand changes in bay water quality relative to nutrients. Work in this area may include monitoring or support of partner efforts to monitor bay water quality. This information will become even more relevant as a number of management changes occur within the watershed, including the completion of the Los Osos wastewater treatment plant and new regulations concerning nutrient runoff from agricultural lands.

C. Stormwater management – Stormwater can transport nutrient pollution to creeks and the estuary, and the impact can vary depending on the variability in annual precipitation patterns. This focus area overlaps with the stormwater management focus for bacteria and will utilize similar actions to address the issue.

Toxics

Over the next five years, the Estuary Program will prioritize its efforts to address toxic pollutants by the following focus areas:

A. Marina and boat-related toxics – A variety of toxic chemicals may be used in activities related to marina and boat maintenance – oil, gasoline, cleaning compounds, paint, and paint remover. Boating

and marina activities can also produce marine debris. The Estuary Program will continue its partnership with the Morro Bay Harbor Department and other entities to implement projects designed to reduce toxic inputs to the bay. Past efforts include removal of abandoned vessels and illegal moorings, purchasing supplies for oil spill preparedness, and providing proper disposal facilities.

B. Education to reduce toxics use near the bay – There are many uses for chemicals in coastal communities that can enter the estuary through stormwater runoff and other means. Examples include landscaping chemicals, car washing detergents, and chemicals from car batteries and other electronics. Work in this focus area will focus on education and outreach activities to increase awareness of bay-friendly alternatives and proper disposal of hazardous waste.

C. Emerging contaminants – Emerging contaminants are chemicals that may be impacting water quality but are poorly understood. These chemicals may come from a wide variety of sources, such as pharmaceuticals, detergents, and household cleaning products. Testing for these compounds can be complex and expensive. Furthermore, interpreting results is difficult because many emerging contaminants are not regulated and do not have guidelines for appropriate concentrations in waterbodies. Given this high level of uncertainty, the Estuary Program recognizes the need for increasing the understanding of what emerging contaminants may be present in the Morro Bay watershed. Activities in this area are likely to focus on determining possible emerging contaminants and encouraging research efforts to determine their likely effect.

Freshwater Flows

Over the next five years, the Estuary Program will focus its efforts to address freshwater flows on the following focus areas:

A. Water budgets – One challenge in addressing limited freshwater flows in the watershed is a lack of understanding regarding the water budget of each sub-watershed (Chorro Valley and Los Osos Valley). A water budget includes the inputs (precipitation, irrigation, piped water, etc.) and outputs (evapotranspiration, runoff, infiltration, and human water use) of water in a specific region. The Estuary Program will participate in efforts to define these water budgets to better inform water conservation and freshwater flow management.

B. Integrated water management – The state of California requires integrated regional water management plans for regions to be eligible for certain state funds. These plans provide an opportunity to promote and practice integrated water management locally by developing an integrated approach to ensuring sustainable water uses, reliable water supplies, and improved water quality. The San Luis Obispo County plan also addresses ecosystem preservation and restoration, groundwater monitoring and management, and flood management.[23] The Estuary Program supports this formal County effort, as well as other more informal efforts to integrate water management, and will continue to support partners in these endeavors.

C. Water conservation and education – One of the central tenets of good water management is water conservation, especially in the climate of the Morro Bay watershed. Local water supplies are limited; the City of Morro Bay, California Men's Colony, and Cuesta College depend on the State Water Project for a significant portion of their water resources due to the scarcity of local resources. The Estuary Program has completed some past outreach and education efforts concerning water conservation at the household level and will strengthen these efforts in the future. The Estuary Program will also support local agencies in improving water conservation at a broader scale.

D. Increase infiltration – Groundwater resources are an important component of local water supplies; in Los Osos, water purveyors rely solely on groundwater for their supply. Individual landowners in rural

[23] San Luis Obispo County Water Resources. 2007. San Luis Obispo County Integrated Regional Water Management Plan. San Luis Obispo, CA. Accessed at: http://www.slocountywater.org/site/Frequent%20Downloads/Integrated%20Regional%20Water%20Management%20Plan/July%202007%20Plan%20Update/index.htm

parts of the watershed also rely on groundwater wells. Increasing infiltration improves groundwater resources and also reduces stormwater runoff, which can carry pollutants to creeks and the estuary. Estuary Program efforts in this area will include: demonstration projects for landscaping and other practices that can increase runoff; support for landowners and resource managers in implementing infiltration practices; and encouragement of low impact development within the watershed.

Biodiversity

Over the next five years, the Estuary Program will prioritize its efforts preserve biodiversity by the following focus areas:

A. Management of invasive species – Invasive species are non-native plants, animals, insects, and diseases that can degrade habitats and out-compete native species. These invaders can take over entire habitats and alter how the ecosystem functions. Reducing invasive species populations, as well as preventing new occurrences, is an important step in preserving biodiversity and ecosystem function. Work in this focus area will follow the Morro Bay Invasive Species Action Plan.[24]

B. Supporting the integration of disparate planning efforts that impacts habitats and biodiversity in the Morro Bay watershed – Many types of planning occur in our local communities – land use planning, water use planning, and species recovery planning are just a few examples. Different agencies and organization undertake these planning efforts, often with little or no coordination. As the sole ecosystem-based management organization in the Morro Bay watershed, the Estuary Program can fulfill the role of helping these efforts occur in a more collaborative fashion. Although the Estuary Program holds no regulatory authority, it can serve as a conduit of scientific and management information, facilitate collaboration, and provide unique insight on the environmental state of the watershed.

C. Increasing our understanding of reference conditions to inform effective restoration – Before conservation activities can occur, the reference condition for a site must be well understood. "Reference condition" refers to the status of a particular site or region prior to the impact that needs to be removed. There are many areas in the Morro Bay watershed where better understanding the reference condition would facilitate more effective conservation actions. The Estuary Program will continue to implement a variety of restoration projects (described in the Ecosystem Conservation and Restoration section of action plans) and will strive to do so with a greater understanding of reference conditions.

Environmentally Balanced Uses

Over the next five years, the Estuary Program will focus its efforts to address environmentally balanced uses on determining the key areas of concern under this priority issue and developing approaches to address those concerns. This priority issue is a new realm in which the Estuary Program has little past experience implementing projects. The Estuary Program will take this opportunity to gather input from local stakeholders, including resource managers, the general public, and specific user groups, to determine their concerns about balancing a variety of uses in the watershed while maintaining and healthy and robust environment. Entities in other regions that deal with similar issues will also be consulted for their expertise. This knowledge-gathering phase will also act as an opportunity to educate different users about the Estuary Program and learn what role the organization can play in addressing this priority issue. At the end of this time period, the Estuary Program anticipates completing a well-developed plan outlining the organization's role in addressing this priority issue and implementation actions that can be taken to fulfill that role.

[24] Jon Hall. 2010. Morro Bay Invasive Species Action Plan. Morro Bay National Estuary Program, Morro Bay, California.

CCMP ACTION PLANS

Land Acquisition

The most direct and effective way to protect certain watershed and estuarine resources is to purchase land or conservation easements. The Estuary Program has partnered with several public agencies and non-profits in land and easement purchases since 2000. Generally, the Estuary Program provides funds that leverage much larger amounts of money from other sources. This funding can be especially effective in meeting costs not usually covered by funding sources, such as title reports, appraisals and resource assessment studies. Besides contributing money, the Estuary Program may also provide technical expertise or supporting educational materials to help attract support for a project.

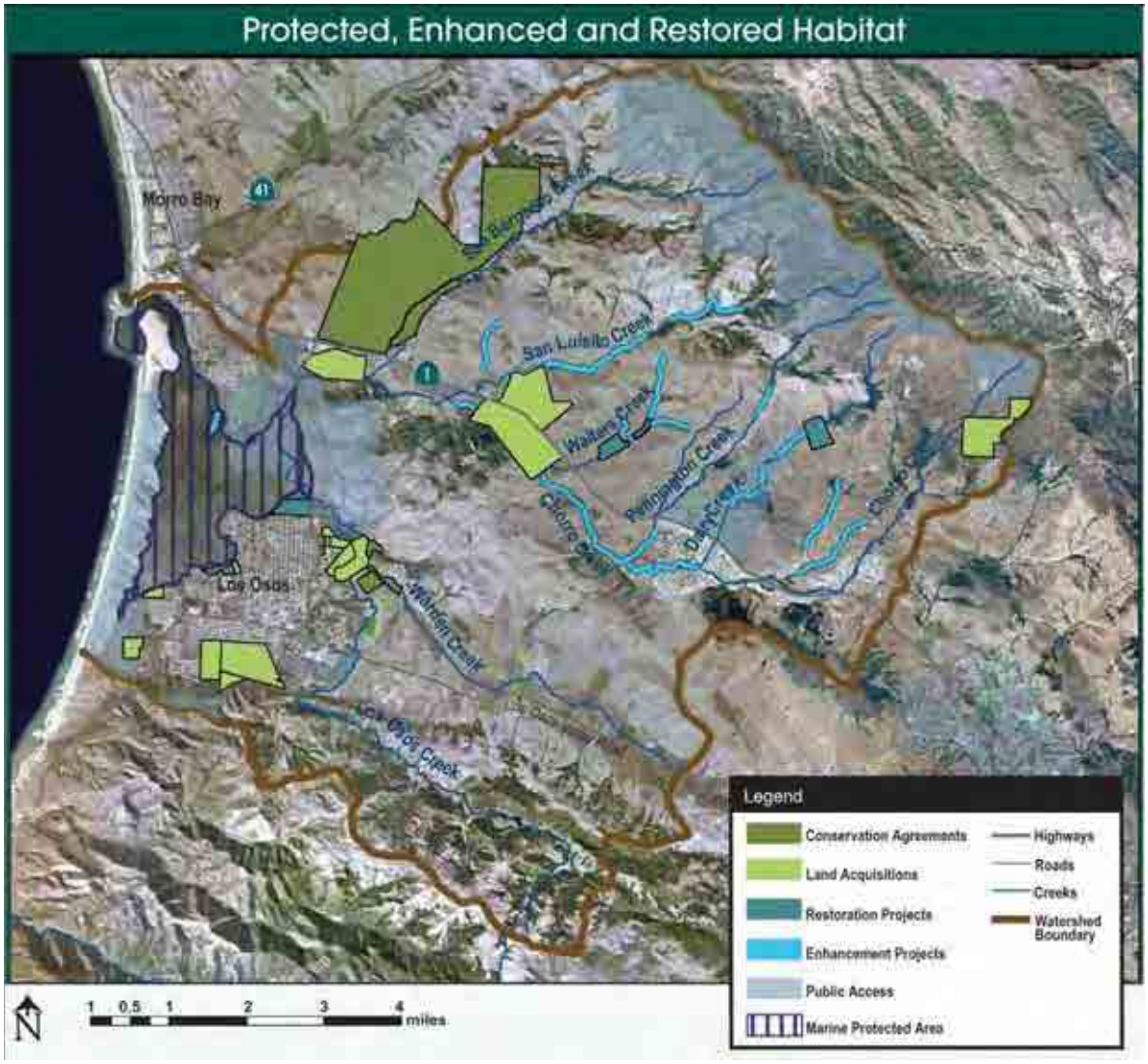
Outright purchase is the most expensive approach and makes sense when ownership is important to implement extensive restoration or other conservation approaches. An example is the Chorro Creek Ecological Reserve, the purchase of which discontinued water-intensive agriculture and paved the way for future modifications of levees and floodplains. These types of actions would be extremely difficult to achieve through land easement agreements.

In other cases, conservation easements can be an excellent tool for reducing threats from specific land uses and promoting land practices that preserve natural resources and local heritage. Conservation easements are agreements in which the landowner sells some or all development or other rights associated with the land but retains the fee ownership of the land. For example, the Maino Ranch Conservation Easement limits development and protects on-site riparian resources while also extending a greenbelt around the city of Morro Bay. The Maino family maintains fee ownership of the land and its ranching operation.

The Estuary Program takes a strategic approach to land acquisition, often focusing on target properties that are important for achieving specific resource goals; however, acquisition must also be opportunistic and take advantage of market conditions, funding availability and initiatives by partners, all of which may arise unexpectedly. In considering whether or not to participate in a land acquisition project, one key factor is the assurance of appropriate and reliable ongoing stewardship of the property after purchase.

The following discusses land acquisitions for specific purposes, keeping in mind that many such acquisitions can achieve multiple objectives. In all cases, the Estuary Program only participates in acquisitions involving willing landowners.

Figure 3: *Map of areas protected, restored, and enhanced in the Morro Bay watershed as of 2011. (Note: Map does not include a parcel purchased by the Bay Foundation in 2011 in Los Osos, at 4th Street and Santa Lucia Avenue. That parcel is 0.28 acres.)*



PROTECT SPECIAL HABITATS AND SPECIES

LA-1 Participate in the purchase of fee title or easements to protect or enhance critical species, sensitive habitats, or areas that provide connections and transitions between habitats. *(Related 2001 action: CC-1)* ⦿

The Morro Bay estuary and its surrounding watershed contain unique and rare habitats, including the coastal dunes complex and maritime chaparral, which are home to numerous special status plants and animals. Land acquisition, by fee title or easement, has been and will continue to be an important method for protecting these resources from a variety of threats, among them development, habitat fragmentation and degradation, and floodplain alterations. In addition to these threats, climate change may alter existing habitat patterns or make certain habitats vulnerable to inundation or other changes. An important consideration when determining suitability for acquisition is whether a parcel, coupled with its surroundings, has the potential to be resilient in the face of such changes. "Resiliency" refers to the capacity of an ecosystem to absorb disturbances and still retain its basic function and structure.[25] The total landscape of protected lands in the watershed will ideally provide not only resiliency but also opportunities for important habitats and species to migrate to more suitable conditions under altered climate scenarios.

In all cases, the Estuary Program only participates in acquisitions involving willing land owners.

Partners: Organizations that provide technical expertise and funding for these types of acquisitions include TNC, TPL, Land Conservancy of SLO, California State Coastal Conservancy, DFG and WCB, DPR, USFWS and the Bay Foundation. Those that have been involved in holding or managing land and easements include DFG, DPR, CSLRCD, Land Conservancy of SLO, County of San Luis Obispo, Morro Coast Audubon Society, SWAP, and the Bay Foundation. *(See Chapter 4 for a full list of acronyms used in this document.)*

Timeframe: Ongoing; purchases are contingent on willing landowners, funding availability, market conditions and the conservation goals of partners.

Cost: $$$ - $$$$

Cost varies greatly with market conditions and location. In-fee acquisitions of shoreline properties have cost as much as several hundred thousand dollars per acre, while other inland conservation easements have cost nearer to $1000 per acre. In all cases, the Estuary Program aims to leverage much larger funding amounts with its financial participation.

Implementation Tracking: Acres purchased or placed in conservation easements. Ratio of funding provided vs. funding leveraged to complete a purchase.

[25] Thompson, I., Mackey, B., McNulty, S., Mosseler, A. 2009. Forest Resilience, Biodiversity and Climate Change. A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 43, 67 pages.

FLOODPLAINS AND SEDIMENT TRAPS

LA-2 Participate in the purchase of restorable floodplains and areas suitable for sediment capture.
(Related 2001 actions: SED-2, CC-2) ⦿

Rapid sedimentation, one of the priority issues for the Estuary Program, threatens the integrity of the Morro Bay estuary and bay, in terms of both habitat and socio-economic values (see Chapter 2 for a further discussion on sedimentation). An important strategy to reduce the amount of sediment reaching the bay is the restoration of floodplains that naturally capture sedimentation upstream. Much of the historical floodplain, especially in Chorro Valley, has been modified by levees for development or farming. Opportunities to restore floodplains to a more natural state or to construct sediment capture basins have been identified, and others may exist. Because floodplain restoration and sediment basins typically require modification of the existing conditions, in-fee acquisition is usually required to achieve this goal.

Acquisitions and easements can also aid in the successful implementation of sediment-reducing Best Management Practices (BMPs). Purchasing a property with significant erosion issues can make implementation of BMPs quicker, easier, and more effective. Such BMPs are discussed in more detail in the Best Management Practices section of this chapter.

Partners: Organizations that provide technical expertise and funding for these types of acquisitions include TNC, TPL, Land Conservancy of SLO, California State Coastal Conservancy, DFG and WCB, DPR, USFWS and the Bay Foundation. Those that have been involved in holding or managing land and easements include DFG, DPR, CSLRCD, and Land Conservancy of SLO.

Timeframe: Ongoing; sites suitable for these functions are limited and their acquisition must be contingent on willing landowners, as well as funding availability.

Cost: $$$-$$$$

Cost varies with location; refer to cost explanation for LA-1.

Implementation Tracking: Acres acquired for floodplain restoration or sediment traps. BMPs implemented by acreage. Ratio of funding provided vs. funding leveraged to complete a purchase. Trends in water quality improvement, such as turbidity, as applicable to the project.

STRATEGIC URBAN DEVELOPMENT

LA-3 Participate with public and non-profit partners in the purchase of fee title or easements in strategic locations to help guide development toward existing and strategically planned communities.

Activities in the watershed strongly influence the ongoing ecological health of the estuary. Development in the watershed can contribute a wide range of pollutants to stormwater and freshwater flow, impact populations and habitats of special status species, and compete directly with non-urban uses for land and water resources. California's approach to coastal development attempts to balance development needs with environmental integrity, ecosystem services (including flood protection provided by certain coastal habitats), and the local sense of place. Local governments and the California Coastal Commission specify the areas in which urban development and other land uses can occur through land use plans and development codes. Nonetheless, continued population growth and development needs may increase pressure to adjust those boundaries and alter land use planning guidance that currently benefits the estuary.

The most effective, long-term method for limiting the impacts of urban development on the estuary and watershed is to develop "greenbelts" around existing developed areas, primarily Los Osos/Baywood Park and the City of Morro Bay, and to a lesser extent, the county and state facilities (such as California Polytechnic University) on the San Luis Obispo side of the watershed. Greenbelts are stretches of undeveloped land surrounding existing communities, serving the purpose of encouraging future development within existing communities rather than developing sprawl on the outskirts of urban areas.

Significant progress has been made in establishing greenbelts in the watershed. A necklace of publicly held open space parcels largely surrounds Los Osos, although some urban development has occurred beyond that greenbelt. Expansion of the City of Morro Bay into the Chorro Valley has been effectively controlled by largely contiguous public lands and conservation easements. The largest single parcel in this greenbelt is the 1,860-acre Maino Ranch easement held by the Bay Foundation. The City of San Luis Obispo has also assembled several parcels into a greenbelt, which may help control encroachment into the watershed from inland.

Impacts from development can also be limited by acquiring parcels planned for intensive urban uses. One example is the urban development proposed on large parcels in the Chorro Valley near Hollister Peak. Although the necessary permits were not approved, the threat of large-scale development was permanently extinguished only with the acquisition of what is now the Chorro Creek Ecological Reserve.

Additional opportunities for preventing the conversion of the estuary's relatively undeveloped watershed into urban intensity uses are likely to arise in the future.

Partners: Organizations that provide technical expertise and funding for these types of acquisitions include TNC, TPL, Land Conservancy of SLO, California State Coastal Conservancy, DFG and WCB, DPR, USFWS and the Bay Foundation. Those that have been involved in holding or managing land and easements include DFG, DPR, CSLRCD, Land Conservancy of SLO, County of San Luis Obispo, Morro Coast Audubon Society, SWAP, and the Bay Foundation.

Timeframe: Ongoing; purchases must be contingent on willing landowners, funding availability, market conditions and the goals of other partners.

Cost: $$$ - $$$$

Cost varies with location; refer to cost explanation for LA-1.

Implementation Tracking: Acres purchased or placed in conservation easements. Extent and continuity of greenbelts. Ratio of funding provided vs. funding leveraged to complete a purchase.

CONSERVATION OF WATER RESOURCES

LA-4 Participate with public and non-profit partners in the purchase of fee title or easements to reduce the use of water resources for intensive agriculture or urban development. *(Related 2001 action: FLOW-3)*

The estuary's principal freshwater sources, Chorro and Los Osos Creeks and their tributaries, often experience extremely low flows and become seasonally intermittent in certain places, potentially harming significant ecological resources. The Mediterranean climate of California's central coast generates extreme and unpredictable seasonal fluctuations in precipitation, which drives such patterns of irregular flow. Withdrawals from shallow aquifers that are closely associated with streams can exacerbate low-flow or dry creek bed conditions and contribute to detrimental environmental impacts, such as loss of aquatic organisms and riparian vegetation.

Purchasing land or easements that specifically limit water-intensive uses can help alleviate the pressure on local surface water resources. For example, hundreds of acres of the Chorro Creek Ecological Reserve were cultivated with orchards and row crops. Purchase of the property allowed for the removal of the orchards and irrigation system, and the discontinuation of water-intensive farming. The Maino Ranch easement is another example where the terms of the easement explicitly limit the acreage that can be used for irrigated farming.

Partners: Organizations that provide technical expertise and funding for these types of acquisitions include TNC, TPL, Land Conservancy of SLO, California State Coastal Conservancy, DFG and WCB, DPR, USFWS and the Bay Foundation. Those that have been involved in holding or managing land and easements include DFG, DPR, CSLRCD, and Land Conservancy of SLO. Other partners include Trout Unlimited, State Water Board, Water Board, city of Morro Bay, and LOCSD.

Timeframe: Ongoing; purchases are contingent on willing landowners, funding availability, market conditions and the goals of other partners.

Cost: $$$ - $$$$

Cost varies with location; refer to cost explanation for LA-1.

Implementation Tracking: Water rights altered, if any, by land acquisition or easement. Projected reductions in water use due to acquisition or easement. Ratio of funding provided vs. funding leveraged to complete a purchase.

ENHANCE PUBLIC RECREATION OPPORTUNITIES

LA-5 Participate with public and non-profit partners in the purchase of fee title or easements to allow for enhanced public access or recreational opportunities with minimal environmental impact. *(Related 2001 action: EDU-8)* ★

Among the important uses of watershed and estuarine resources is public access for recreational uses consistent with the protection of the environment. Thus, in some cases, the Estuary Program may participate in the acquisition of land for public access and recreational purposes, especially when the purchase also contributes to resource protection directly or through enhanced public education opportunities. The Estuary Program may also support improving public access on already protected properties if such access is compatible with the preservation of the natural resource present.

An example of a highly accessible and well-preserved parcel is the Elfin Forest in Los Osos. This unique pygmy oak forest has been protected from future development and carefully restored by the tireless efforts of Small Wilderness Area Preservation (SWAP), a local conservation organization. The Estuary Program supported SWAP's efforts to install and maintain a wheelchair accessible boardwalk through the preserve. This boardwalk provides an important public access opportunity while also protecting native species and habitats found on the land.

Partners: Organizations that provide technical expertise and funding for these types of acquisitions include TNC, TPL, Land Conservancy of SLO, Coastal Conservancy, DPR, and the Bay Foundation.

Timeframe: Ongoing; as noted above, purchases are contingent on willing landowners, funding availability, market conditions and the goals of other partners.

Cost: $$$ - $$$$

Cost varies greatly with market conditions and location; refer to cost explanation for LA-1.

Implementation Tracking. Acres of land opened to new or enhanced public access. Ratio of funding provided vs. funding leveraged to complete a purchase.

Water Quality Standards and Monitoring

Congress created the National Estuary Program under the federal Clean Water Act (Section 320), recognizing that protecting water quality in estuaries and their watersheds preserves their unique biological significance as well as the many human activities they support. To protect water quality and the important uses that occur within estuaries and their watersheds, the National Estuary Program strives to achieve two foundational goals – support the establishment of appropriate water quality standards and monitor progress toward meeting those standards.

The Central Coast Regional Water Quality Control Board (Water Board) is the state agency that sets water quality standards in the Morro Bay area. The Water Board establishes Total Maximum Daily Loads (TMDLs) for impaired waterbodies in Morro Bay pursuant to Section 303 of the Clean Water Act.
Impaired waterbodies are first identified through data analysis and then classified as "listed" pursuant to CWA 303. Waterbodies can be "de-listed" when water quality improves. If water quality does not improve, the Water Board develops a TMDL that identifies an allowable level of a pollutant for an impaired water body. When developing TMDLs, the Water Board takes into account all pollution sources, including point sources, nonpoint sources, and natural background loading. Waterbodies that achieve their TMDLs are considered acceptably clean to support the biological values and human activities that depend on them.

The Water Board also issues permits to persons and agencies that discharge water into the ocean, estuary, and creeks. Such permits include conditions to protect water quality and minimize environmental impacts.

Other agencies set water quality standards for specific pollutants related to specific uses. For example, the California Department of Public Health (DPH) closely regulates pathogen indicators and biotoxins in waters open for commercial oyster farming and where shellfish is sport-harvested. Oyster harvesting is suspended when bacteria levels exceed acceptable limits. Similarly, the San Luis Obispo County Environmental Health Services ensures that water quality in the county is sufficiently safe for human contact during recreational activities such as swimming, fishing and boating. The California Coastal Commission addresses water quality in the coastal zone through its permitting process. Projects in the coastal zone must meet the Coastal Act's requirements for protecting water quality and the Coastal Commission considers these requirements when issuing permits.

The Estuary Program has played a major role for more than a decade in monitoring water quality and related measures of environmental health. To a large extent, the program relies on specially trained volunteers that participate in the Volunteer Monitoring Program (VMP). VMP-collected data has been used by the Water Board, DPH, and other agencies to track a wide variety of pollutants and other environmental indicators in the watershed. VMP activities are managed by the Estuary Program staff and are carried out pursuant to a Quality Assurance Project Plan (QAPP) approved by the USEPA and Water Board.

Certain parameters require monitoring expertise or techniques that are not appropriate for volunteers. In such cases, the Estuary Program may utilize its professional staff or contractors to undertake the work. In addition, the Estuary Program has partnered with other organizations, notably the San Luis Obispo Science and Ecosystem Alliance (SLOSEA), to augment the monitoring conducted by the VMP.

Besides monitoring changes to the estuary's environmental health, the Estuary Program also measures the effects of projects that are undertaken to improve water quality. For example, the Estuary Program tests the water quality upstream and downstream of projects that implement best management practices to assess the effectiveness of the projects on stream water quality.

It is worth noting that the two types of monitoring – project effectiveness versus systemic changes – have very different time scales and geographic scopes. In allocating its resources (staffing, volunteers or funding), the Estuary Program recognizes these differences and strives to balance the needs for both types in developing a fuller picture of the estuary's health.

TOTAL MAXIMUM DAILY LOADS (TMDLS)

MON-1 Support Central Coast Regional Water Quality Control Board in monitoring progress and reporting on TMDLs, or similar standards for pollutants, relevant to the estuary and its water bodies. Participate in any future TMDL reviews and revisions. *(Related 2001 action: CC-3)*

The Estuary Program participates in monitoring and reporting on TMDLs in the Morro Bay watershed to aid regulators in better understanding progress being made toward TMDL requirements. The data collected by the Estuary Program volunteers and staff is provided to the Water Board for updates to the TMDLs and 303(d) listings. Without the Estuary Program data, the Water Board would be relying on extremely limited data in the watershed to measure progress. The Estuary Program will continue to collect and share data to help motivate progress toward improving water quality and demonstrate change.

The following TMDLs apply to water bodies in the Morro Bay watershed[26]

- Dissolved Oxygen – Chorro Creek, Dairy Creek
- Sediment – Chorro Creek, Los Osos Creek, and the Morro Bay estuary
- Pathogens – Morro Bay estuary, Chorro Creek, Los Osos Creek, Dairy Creek, and Warden Creek
- Nutrients – Chorro Creek, Los Osos Creek, and Warden Creek and Lake Wetland

At one time, Chorro Creek was considered impaired by the presence of certain heavy metals that were historically mined in the upper watershed. During the past decade, the creek was de-listed for those constituents as information about the natural background levels was better understood.

The current sediment TMDLs for all three water bodies (Chorro Creek, Los Osos Creek, and the Morro Bay estuary) relies on tracking implementation projects to achieve its goals. Loading reduction estimates are used to predict progress as implementation projects are completed. Although loading is the most direct measure of progress, it requires an extraordinary amount of data to calculate and does not fully capture variability due to weather, seasons and flow volumes. The Estuary Program will support efforts to explore alternative measures of progress besides loading for sediment TMDLs. Activities that the Estuary Program may undertake to support TMDL monitoring and reporting include

- Monitoring in creeks and estuary for constituents listed in TMDLs, as monitoring capabilities allow
- Analyzing monitoring data in formats usable for the TMDL process
- Monitoring of implementation projects to demonstrate effectiveness in meeting TMDL benchmarks

Partners: Water Board, State Water Board, USEPA

Timeframe: Ongoing.

Cost: $$

To large extent, this action plan occurs within the usual scope of the Estuary Program functions including the VMP (see MON-5) and costs are likely to overlap with other action plans in this section.

Implementation Tracking: Regular reports on the status of TMDL compliance in impaired water bodies, in conjunction with the Water Board's triennial review of each TMDL.

[26] All current and proposed TMDLs for the Morro Bay watershed can be found online at the Central Coast Regional Water Quality Control Board's website: http://www.swrcb.ca.gov/rwqcb3/water_issues/programs/tmdl/303d_and_tmdl_projects.shtml. A copy of all current TMDLs is also kept at the Estuary Program office and can be accessed by request.

MONITORING APPROACHES

MON-2 Monitor a suite of environmental indicators that can be used to track changes to the estuary and watershed and that are supportive of state water quality and biological objectives; the selection of appropriate indicators should consider factors such as how well the indicator demonstrates the health of the environment, priority issues of the Estuary Program, reliability of methodology, and costs (time, staff, funding).

The estuary and its watershed is a complex system with many influences from both the land and ocean. Measuring the health of such a dynamic environment is a difficult task, but it is one of the Estuary Program's most crucial roles. Numerous partners rely on Estuary Program monitoring data to inform management decisions and demonstrate improving conditions from various projects. In addition, the Estuary Program is an important source of water quality data for the public to learn more about their local environment.

In trying to understand such a complex system, there is a wide array of interrelated variables that can track environmental change. It is impossible, and inefficient, to monitor all potential measures, so the Estuary Program must focus on a specific suite of water quality, biological, and related environmental indicators. The chosen indicators are usually relatively easy to monitor and are cost-effective, while also being strongly linked to the wider environmental health of the system. In addition, the Estuary Program also chooses indicators that support the water quality objectives of partner agencies (such as the Water Board). This collaborative approach increases the cost-efficiency of monitoring, while painting a more complete picture of how the estuary and watershed are changing.

The Estuary Program recognizes that as technology and scientific understanding change, new pollutants, standards, and protocols will evolve. At the time this plan was written, some potential pollutants not currently regulated, called "emerging contaminants", were being investigated for their water quality and biological impacts in Morro Bay. The Estuary Program endeavors to adapt to such changes by regularly reviewing and updating its monitoring program and the indicators being measured. The program must strive to strike a balance between adapting to new approaches and issues while also maintaining important long-term datasets.

A developing approach to measuring water quality is the use of biological objectives, as opposed to the more typical chemical analyses. Biological objectives measure changes in aquatic biota in a waterbody. Monitoring aquatic organisms provides a more complete picture of water quality and the net impact of pollutants on aquatic life. This approach to measuring water quality is becoming increasingly important and the Estuary Program has already begun learning new methods to incorporate biological objectives into its monitoring program. The Estuary Program will continue to adapt as state and regional water quality regulators move toward using more sophisticated biological objectives and criteria.

Monitoring may also include approaches to help ascertain the effects on the estuary from major infrastructure or management decisions, such as the pending Los Osos wastewater treatment system.

Activities to support this action plan may include

- Continued monitoring of environmental indicators known to be useful in tracking environmental change and informing regulatory partners
- Supporting advancement of biological objectives to determine impacts of water quality on aquatic life
- Tracking of scientific progress in determining emerging contaminants of concern and monitoring those contaminants if water quality impacts are suspected and analysis is not cost or labor prohibitive

Partners: Water Board, State Water Board, USEPA, DPR, NOAA NMFS, Cal Poly including SLOSEA, California Coastal Commission, DPH, ACOE, SLO County, City of MB, LOCSD, Aquaculture operators

Timeframe: Ongoing.

Cost: $$

Costs for this action are partially encompassed within the scope of the VMP (See MON-5) but includes other efforts such as evaluating sediment levels and eelgrass surveys. The cost of these specific studies is variable with its nature and scope, but annual expenses can exceed $50,000.

Implementation Tracking: A current suite of variables being monitored. Tracking of use of Estuary Program data by partners and regulatory agencies. Entry of the Estuary Program data into California-wide water quality database(s) used by stakeholders and regulatory agencies.

MON-3 Support the development of environmental indicators and engage in monitoring to contribute to project evaluation in the Morro Bay estuary and watershed; the development of indicators and methodologies should consider factors such as the needs/requirements of funders and partner agencies; meaningfulness and potential for reliable replication over time; and costs (time, staff, funding).

The Estuary Program is not only concerned about how the entire estuarine system is changing over time, but also how specific projects aimed at improving water quality and other environmental conditions are performing. Evaluating the effectiveness of projects helps adapt current efforts and refine future practices to most efficiently generate positive changes. The nature of each specific project determines the methods required to monitor effectiveness. For example, a riparian fencing project might necessitate bacteria monitoring while a floodplain restoration project may require monitoring changes in sediment transport. Other considerations for project evaluation include cost, ease of replication, and the requirements of partner and funding agencies. Beyond water quality, monitoring under this action also addresses habitat restoration measures of success, such as vegetative cover, use of restored site by certain species, and restoration of specific ecosystem functions.

Activities to support this action plan may include

- Development and execution of monitoring plans for restoration projects implemented by the Estuary Program and partners
- Analysis of project-specific monitoring data to demonstrate impacts on water quality objectives and habitat restoration measures

Partners: USEPA, DFG, CSLRCD, NOAA NMFS, Cal Poly including SLOSEA, Water Board, university and research institutions

Timeframe: Ongoing (specific timeframes set for each project being evaluated).

Cost: $$

Implementation Tracking: The number and scale of project performance monitoring efforts and evaluation results. Reporting the use of monitoring data to demonstrate impacts and adapt future projects.

VOLUNTEER MONITORING PROGRAM

MON-4 Maintain a high quality Volunteer Monitoring Program to track environmental variables appropriate for volunteer involvement and meaningful to the program and its partners. *(Related 2001 action: CC-6)* ★

Morro Bay's Volunteer Monitoring Program (VMP) is a model of citizen-based science emulated by groups nationwide. During the last decade, hundreds of volunteers have contributed thousands of hours to the program. Volunteers have collected data related to a wide variety of variables, including water pollutants, physical parameters of water quality, geomorphic and hydrodynamic changes in creeks and the bay, sedimentation, the distribution and abundance of species and habitats, biological productivity, and project effectiveness. This data informs the Estuary Program's decisions about implementing restoration projects and is also used by a number of partner agencies. The Water Board, DPH, City of Morro Bay, County of SLO, LOCSD, California Coastal Commission, DFG, NOAA NMFS, and DPR all use VMP data to inform management and regulatory decisions within the Morro Bay watershed. VMP data contributes to the writing and revision of TMDLs, 303(d) listings, and warnings about recreational contact in certain waterbodies. Private landowners also use VMP data to manage a variety of land uses. All monitoring activities are conducted pursuant to a Quality Assurance Project Plan (QAPP) approved by the Water Board and USEPA. Volunteers undergo extensive training to meet those approved protocols. Morro Bay's QAPP is frequently cited as a model for other monitoring programs.

Beyond collecting essential water quality data, the VMP serves another important function – connecting the community to the watershed and estuary. By enlisting the public directly in the work of the Estuary Program, the VMP increases awareness of the community's connection to the estuary and how human activities can impact this important place.

The size, scope and sophistication of the VMP necessitate high-level professional support staff. Funding for staff, as well as equipment, testing and data input, is essential to the program's success and requires assistance beyond the funds of the Estuary Program. Activities to continue the VMP and ensure the sustainability of the program well into the future include

- Management of the VMP to ensure high quality data that can be used by a variety of partners
- Continual volunteer oversight to maintain a well-trained and motivated volunteer corps
- Regular training, data sharing, and appreciation events to keep volunteers engaged in the program

Partners: Water Board, State Water Board, USEPA, CCAMP

Timeframe: Ongoing.

Cost: $$$

The current VMP operates on a budget of approximately $200,000 per year for management, training, supplies, data entry, quality control, and data analysis. This budget can vary drastically depending on the variables being monitored and the amount, and level of sophistication, of lab analysis.

Implementation Tracking: Number and types of variables monitored; number and frequency of sites monitored; annual QAPP approval; number of volunteer hours. Number of data reports created that use volunteer-collected data (as well as how those reports are used).

MONITORING PARTNERS

MON-5 Continue to share data and collaborate with federal, state, regional, university and local monitoring partners.

Many agencies and organizations in the Morro Bay area need monitoring data regarding water quality and environmental conditions in order to do their work. One outstanding example of water quality monitoring is the Water Board's Central Coast Ambient Monitoring Program (CCAMP) that has collected, analyzed, and disseminated data on water quality in creeks and rivers between Santa Cruz and Santa Barbara counties, including those in the Morro Bay watershed. The Estuary Program has participated with CCAMP on database support, determining data collection needs at specific sites, equipment and data sharing, and conducting staff professional development activities. Other agencies that monitor variables relevant to the Estuary Program include DPH, County of SLO, City of Morro Bay, LOCSD, CSLRCD, DFG, DPR, NOAA NMFS, as well as non-profit and university groups such as SWAP, the Land Conservancy of SLO, and SLOSEA. The Estuary Program will continue its efforts to regularly collaborate with all of these groups to share data and equipment and reduce duplicative efforts. Supporting activities may include

- Aligning constituents monitored, methods used, and analysis approaches with CCAMP, local partners, and state monitoring standards to ensure transferability of data
- Providing technical support and local planning assistance for monitoring efforts by partners
- Data sharing to support monitoring efforts of SLOSEA, CCAMP, and other partners

Partners: Water Board, CCAMP, DPH, County of SLO, City of Morro Bay, LOCSD, CSLRCD, DFG, DPR, NOAA NMFS, SLOSEA

Timeframe: Ongoing.

Cost: $$

To a large extent, this type of collaboration occurs within the usual scope of the Estuary Program functions and is embedded in overall program costs. However, future collaborations that involve collecting additional data will require additional funding for staff, equipment, testing and analysis.

Implementation Tracking: The number of agencies with which the Estuary Program has collaborative monitoring relationships. The number and frequency of data sharing mechanisms the Estuary Program employs, including adding data to regional and state databases. Inclusion of Morro Bay in state and region-wide water quality studies.

MON-6 Support scientific research and studies that contribute to a better understanding of complex estuary and watershed ecosystem dynamics. Encourage information exchange with research activities.

The Estuary Program is a science-based program that has greatly contributed to better scientific understanding of the estuary and watershed. Although the Estuary Program does not typically directly engage in research activities, it does collect monitoring data used by other entities in research endeavors and occasionally commissions studies to better understand particular environmental issues. The Estuary Program also relies on scientific studies and research results to design restoration projects and monitoring protocols. Partners including the Water Board, DFG, NOAA NMFS, USACOE, California Coastal Commission, the California Energy Commission, TNC, CSLRCD, and the Land Conservancy of SLO, have all contributed to research related to Morro Bay. Among the most important resources, however, is Cal Poly. Three important programs, the Coastal Resources Institute and the Escuela Ranch in the College of Agriculture and SLOSEA in the College of Science and Mathematics, have worked extensively in Morro Bay. Furthermore, individual faculty members across many of Cal Poly's colleges and departments have directed their research interests to the issues of the watershed and estuary. University students, at both the undergraduate and graduate levels, have undertaken useful research relevant to the Estuary Program and its partners. One of the Estuary Program's crucial roles is to encourage and support these entities in continuing to study the many complex environmental dynamics of the Morro Bay estuary.

Activities to support scientific research may include

- Sharing monitoring data and restoration project results to facilitate research efforts
- Providing technical and logistical support for partner research projects
- Guiding research efforts toward projects that will generate information useful to management efforts

Partners: Water Board, DFG, NOAA NMFS, ACOE, California Coastal Commission, California Energy Commission, TNC, CSLRCD, Land Conservancy of SLO, Cuesta College, Cal Poly (especially Coastal Resources Institute, Escuela Ranch, and SLOSEA)

Timeframe: Ongoing.

Cost: $$ - $$$

Cost varies considerably; the majority of funding for research comes from outside sources. The Estuary Program has provided some direct research funding, most notably to SLOSEA, but also regularly provides staff support and data from the VMP and related monitoring work for researchers and scientists.

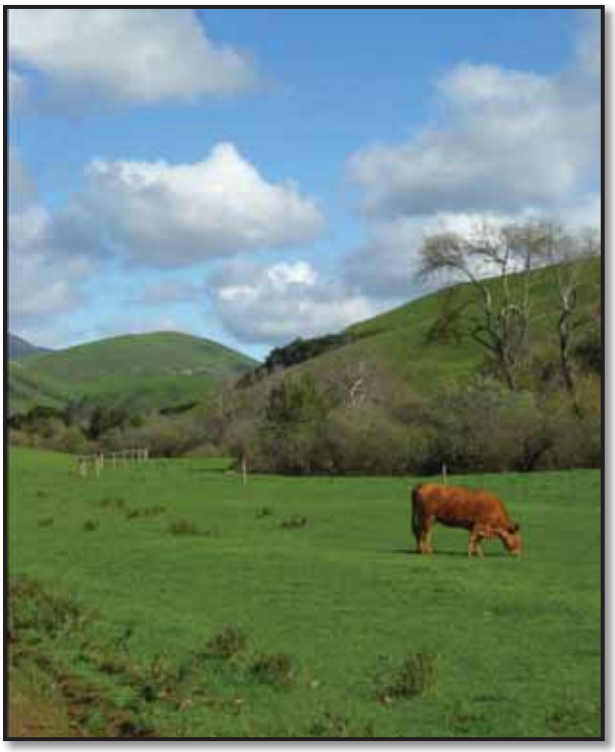
Implementation Tracking: Number and scope of high quality research projects relevant to Morro Bay. Use of research results in management decisions (including restoration projects, monitoring, and regulatory decision making).

Best Management Practices

A wide variety of human activities in the watershed and on the bay impact the health and productivity of the estuary. All such activities – whether farming or ranching in rural lands, living or doing business in the developed towns, or boating on the bay – can be carried out in ways that reduce impacts to natural resources. Effective approaches and tools that prevent or reduce pollution and other environmental impacts are collectively termed "Best Management Practices", or BMPs. BMPs are an important part of voluntary and regulatory programs to improve water quality, but they often require unique knowledge, skills, or tools to implement. The Estuary Program plays a critical role in the community by promoting the implementation of BMPs with programs that share knowledge and skills and leverage funding to support installation of BMP infrastructure.

The following actions support the promulgation and implementation of BMPs relevant to the broad range of land uses that occur in the Morro Bay watershed – agriculture, grazing, rural and urban development, boating and harbor management, and municipal wastewater treatment.

Figures 4 and 5: *Examples of Best Management Practices.*



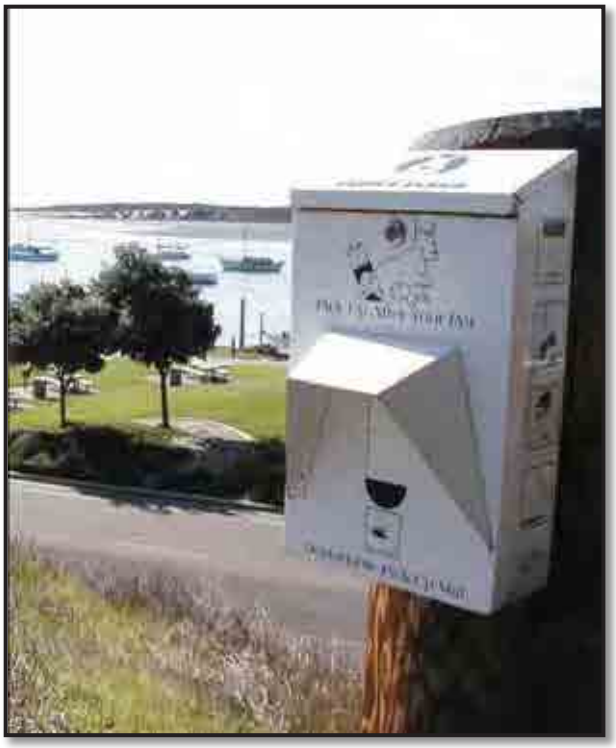


Figure 4 (left): Another effective BMP that helps reduce bacteria pollution is riparian fencing. Riparian fencing restricts access by cattle and other grazers to creeks and streams on ranch lands, thus limiting the amount of animal waste that makes its way into waterways. The Estuary Program has helped install more than 11 miles of fencing in the watershed and has built strong working relationships with local ranch owners and managers to do so. Oftentimes, a riparian fencing project will include developing off-creek water sources to provide cattle with alternative water when they are prevented from accessing streams.

Figure 5 (right): A common BMP implemented in urban areas is Mutt Mitts – specially designed dispensers and bags to encourage pet owners to pick up after their pets in public areas. Waste from pets can be a source of bacteria to nearby water bodies and Mutt Mitts, when used regularly, can play an important role in reducing that source.

AGRICULTURE AND GRAZING

Farming and ranching are important land uses in the watershed, creating food for society, providing jobs and economic stability, and preserving the local agricultural heritage. These valuable activities can also impact water quality in creeks and the estuary. Certain farming and grazing activities tend to exacerbate natural erosion rates, accelerating the deposition of sediment in creeks and the bay. Grazing animals that have free access to creeks can be significant sources of bacteria and sediment to the estuary. Many of the fertilizers used in farming can contribute to high nutrient levels in the creeks and groundwater, and certain pesticides can adversely affect specific plants and animals.

Many landowners in the watershed, both public and private, have proactively implemented or supported BMPs to reduce impacts while allowing for continued, effective farming and ranching operations. Rangeland BMPs include riparian fencing and off-creek water sources, riparian re-vegetation, rotational grazing pastures, reduction in grazing intensity, and other pasture management activities. Agricultural BMPs range from the establishment of vegetated creek setbacks to cultivation practices that reduce the need for fertilizers and pesticides. In addition, erosion caused by unpaved ranch roads can be significantly reduced by proper design, and on-site retention ponds can capture sediment before it reaches creeks and the bay.

For over two decades, many organizations in San Luis Obispo County have helped landowners implement BMPs through both technical and financial assistance. The Estuary Program has strongly supported these efforts, partnering with the CSLRCD, the Natural Resources Conservation District (NRCS), the San Luis Obispo Farm Bureau, UC Cooperative Extension (UCCE), Cal Poly, and numerous private landowners. These partner efforts focus primarily promoting farming and grazing management practices that reduce non-point source pollution. The Estuary Program has also funded educational materials to increase awareness of BMP options, including brochures, workshops, and demonstration programs.

The essential partners in all of these efforts are the landowners themselves, who have altered their practices to benefit the environment while sustaining successful agricultural and ranching practices. Several property owners moved beyond implementing BMPs on their land to actively promoting such practices to their neighbors in the watershed.

BMP-1 Support the implementation of Best Management Practices on agricultural and grazing lands in the watershed through technical assistance, financial assistance, and other incentives, and educational outreach through various media, including workshops and trainings. *(Related 2001 actions: SED-1, SED-4, SED-7, NUTR-3, BACT-1, EDU-3, EDU-4.)* ★

A variety of BMPs exist to reduce impacts from sedimentation, bacteria, and nutrients. These practices may be implemented voluntarily by willing landowners or may be part of regulatory requirements due to water quality issues. Choosing which BMP is appropriate for a particular landowner depends on the primary water quality issue, type of land use, site and funding constraints, ease of maintenance, proven effectiveness of the design, and regulatory requirements. Examples of BMPs that the Estuary Program may support or help implement include

- Riparian fencing projects coupled with off-creek water systems to keep grazing animals out of creeks and provide an alternative water source
- Re-vegetation of the riparian corridor to reduce bank erosion
- Stabilization of failing banks and failing stream crossings
- Rotational grazing plans
- Reduction of grazing intensity, particular at sites near creeks and streams
- Dirt road erosion prevention tactics, such as rolling dips, sloping, and cross ditches
- Planting of stream buffer zones with native vegetation
- Alternative fertilizer, herbicide, and pesticide application systems to reduce total usage and promote more direct application
- Educational materials and training programs to various partners in the agricultural community

Partners: CSLRCD, UCCE, Farm Bureau, private and public land owners, CCC (including the Watershed Crew), DFG, DPR, Coastal Conservancy, Water Board

Timeframe: Ongoing

Cost: $$

Cost depends on the number and scope of projects undertaken in any given timeframe; typical implementation projects can range from less than $10,000 to well over $100,000.

Implementation Tracking: Acres where BMPs are implemented. Number of each type of BMP implemented by sub-watershed. Acres of stream fenced and re-vegetated. Reduction in amounts of fertilizers, herbicides, and/or pesticides used (if data is collected during implementation projects by the Estuary Program and partners). Miles of dirt roads with BMPs implemented. Number of stream crossings and/or banks repaired and amount of sediment retained. Documentation of relevant outreach and education projects completed.

RURAL LANDS

The Morro Bay watershed remains, in large part, in undeveloped or rural lands. Rural lands support a wide range of important activities, including farming, grazing, education, recreation and military training. In the past, the upper watershed was also mined for valuable metals (notably nickel and chromium). Coupled with important human benefits, these land uses can also exacerbate natural erosion processes by increasing the amount of sediment entering creeks and accelerating transport of sediment to the estuary. The following action plans address three strategic approaches to reduce sediment and heavy metal impacts from the activities mentioned.

BMP-2 Support the implementation of BMPs to reduce erosion from rural roads.

Unpaved roads, both abandoned and still in operation, lace most of the rural portions of the watershed. These roads constitute a recognized contributor to sediment loading, and an assessment done in 2008 documented the largest contributors of sediment to fish bearing streams.[27] BMPs have been implemented by both public and private landowners to greatly reduce erosion and increase the functional lifespan of the roads. The Estuary Program contributes toward continued implementation of these BMPs, sometimes directly through projects in the field that are funded wholly or in part by the program, as well as by supporting the distribution of educational materials and related training. The Estuary Program will continue to encourage BMPs on rural roads through activities such as

- Technical and leveraged funding support for rural road improvement by private landowners and public agencies
- Road evaluation and planning assistance to facilitate implementation of BMPs
- Technical support in developing methods to demonstrate success in reducing sediment runoff

Partners: CSLRCD, UCCE, Farm Bureau, CCC including the Watershed Crew, Water Board, private and public landowners, AmeriCorps (Watershed Stewards Program)

Timeframe: Ongoing

Cost: $-$$

Educational materials are relatively inexpensive; actual implementation projects can vary widely in cost depending on their nature and scale.

Implementation Tracking: Miles of rural roads upgraded to current BMP standards. Number of crossings and/or banks repaired and amount of sediment retained. Miles of rural roads decommissioned.

BMP-3 Periodically review, update and help implement a fire management plan for the watershed to reduce erosion following wildfires. *(Related 2001 action: SED-3)* ⦿

Wildfires in the upper watershed, combined with subsequent rains, increase the amount of sediment delivered to the estuary. For example, after the "Highway 41 Fire" of August 1994, which burned 9,700 acres (about 35 percent) of the Chorro Creek watershed, heavy rains fell in the subsequent winter, leading to a tremendous delivery of sediment to Morro Bay. More than five feet of sediment was deposited on some areas of the Chorro Flats floodplain during that single winter.[28] This same scenario can repeat itself in the future unless a planned approach, using prescribed fires and other control techniques, is implemented in the watershed.

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[27] Pacific Watershed Associates, Inc. 2009. 2008 Chorro Creek and Stenner Creek Watersheds Road and Trail Erosion Assessment. San Luis Obispo County, CA. 40pp. Copy available at Estuary Program offices.
[28] Coastal San Luis Resource District. 2002. Chorro Flats Enhancement Project – Final Report to the California State Coastal Conservancy. 48 pp. Accessed at: http://www.coastalrcd.org/images/cms/files/Chorro%20Flats%20final%20report%20smaller.pdf

In 2001, the Estuary Program contracted with Northtree Fire International to develop a fire management plan that identifies high hazard areas and potential strategies for integrating fire and fuels management into long-term ecological restoration projects within the watershed.[29] The plan characterizes the local fire regime and relationships to weather patterns, as well as historical causes of wildfires. Recommended strategies include: prescribed burns to restore the ecological role of fire in the ecosystem and reduce fuel loads; physical removal of fuel; implementation of a strategic fire defense system (i.e. fire breaks, greenbelts, and defensible fuel zones); and fire education and awareness programs.

The fire management plan has been valuable to Cal Fire and local fire protection agencies operating in the watershed. This plan needs to be kept current, especially in light of possible climate changes that may alter historic weather patterns. Activities to support this action plan may include

- Outreach efforts to Cal Fire and local fire agencies to use the plan and evaluate it for updates needed
- Support for updating the plan with leveraged funding and partner support
- Implementation and evaluation of restoration projects to reduce fire risk based on the fire plan
- Continued implementation of fire education and awareness efforts

Partners: Cal Fire, County of San Luis Obispo, City of Morro Bay, USDOF, BLM, USFWS

Timeframe: Review and update the existing plan by 2018.

Cost: $$

Implementation Tracking: Completion of an updated plan. Implementation of plan recommendations (such as acres subject to controlled burns).

BMP-4 Support the remediation of mines in the upper Chorro Creek watershed to reduce downstream sediment and toxic/heavy metals loads. *(Related 2001 action: HMT-1)*

Since the mid-nineteenth century, chromium and nickel were mined in several locations in the Santa Lucia range above the Chorro Valley. Tailings from these mines were once thought to be significant sources of heavy metals, which can be toxic to wildlife in certain concentrations. After several years of monitoring, the Water Board de-listed Chorro Creek and Morro Bay for heavy metals. Although concerns about toxicity have diminished, erosion of the old mines and their tailings continues to be a source of sediment and their remediation is valuable in reducing sedimentation.

The single most significant erosion problem has been associated in the past with a mine on Camp San Luis Obispo. The California Department of the Military has undertaken a large-scale, multi-phased remediation project that has alleviated some of the worst erosion sources. The Estuary Program has supported, and will continue to support, remediation efforts on Camp San Luis Obispo and at other abandoned mines in the upper watershed. Support activities may include

- Technical and leveraged funding support for evaluating remediation feasibility of existing mines
- Implementation of mitigation efforts to reduce erosion resulting from non-remediated mines
- Periodic monitoring or other efforts to ensure that remediated mines are becoming re-vegetated

Partners: Camp SLO, USDOF

Timeframe: Ongoing

Cost: $$$

The overall cost of remediation has run well above $100,000 although individual phases can be less expensive.

Implementation Tracking: Remediation projects completed. Estimated reductions of sediment and metals.

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[29] Northtree Fire International. 2002. Morro Bay Estuary Watershed Fire Management Plan. Marysville, CA, 108 pp. Accessible at the Morro Bay National Estuary Program offices, 601 Embarcadero Suite 11, Morro Bay CA 93402.

URBAN

The Morro Bay watershed has a relatively small urbanized area, with approximately 25,000 residents in about 13 square miles adjacent to the estuary. Urbanization has brought many economic and social benefits to the area, including increased tourism capacity, and has resulted in vibrant, livable communities. Urban development has also impacted the surrounding environment, particularly by increasing storm water runoff volume, velocity, and pollutant loadings. The impervious surfaces associated with development reduce the ability of the land to absorb and filter rainwater. Activities in urbanized areas also contribute non-point source pollutants: fertilizers and pesticides used on lawns and gardens; pet waste; silt and sediment from construction projects; and compounds that accumulate on streets and parking lots from automobiles and trucks, such as chemicals, hydrocarbons, soaps, detergents, and metals.

Urbanization also increases water use from the local aquifer and streams. The Los Osos community uses water from the groundwater basin's lower aquifer and is facing saltwater intrusion issues.[30] The upper aquifer contains elevated nitrate concentrations that limit its potable use.[31] Morro Bay relies mainly on imported state water but does pump water from city owned wells adjacent to Chorro Creek and Morro Creek when state water is not available. As these two urban areas grow in population, water demand will also increase. Conserving local freshwater sources is important to the estuary and the health of local streams that depend on certain minimal flows to support riparian communities. Diminished freshwater inputs to the estuary can increase salinity and detrimentally impact a variety of estuarine species that are adapted to brackish waters.

The introduction and spread of invasive species also increases with urbanization. Many invasive species are initially introduced as landscape plants and thereafter spread to natural areas through rigorous seed dispersal mechanisms. Disturbance of natural landscapes from urban activities, including road construction and recreational trails, can also help spread invasive species, which are generally well-adapted to colonize disturbed areas. Both Morro Bay and Los Osos have a strong history of landscaping with native plants, and awareness of invasive species has increased with outreach and education efforts by the local native plant society, master gardeners, and nurseries. Development and urban landscapes also cause habitat fragmentation, which may limit the ability of species to utilize their full habitat range and lead to further habitat degradation.

The diversity of stormwater, water use, and invasive species impacts in urbanized areas necessitates a comprehensive strategy that combines regulation with community-wide education and outreach, as well as incentive-based and volunteer programs. Practical and cost-effective BMPs are essential to any strategy to control, prevent, and reduce impacts from urbanization while maintaining the social benefits of urban areas.

The Estuary Program has worked with local governments to provide educational materials to residents, property owners and business operators to encourage stewardship and the use of BMPs. One example is the Bayside Living Guide, with more than 20,000 copies distributed. Most of the Estuary Program's literature encourages the use of stormwater BMPs.

BMP-5 Support the implementation of Best Management Practices by property owners, residents, visitors, and businesses in urban areas to reduce impacts to the estuary from storm water runoff, water use, and the spread of invasive species. *(Related 2001 actions: NUTR-4, CC-4)* ★

All community members play an integral role in sustaining environmental well-being and maintaining the livability and unique connections to the local environment that Morro Bay and Los Osos enjoy. A variety of BMPs can be implemented to address urban impacts from stormwater runoff, water use, and the spread of invasive species. Some examples of appropriate BMPs include:

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[30] Los Osos Groundwater Basin Update. 2010. Prepared by ISJ Working Group Available through the County of San Luis Obispo and at:
http://www.slocounty.ca.gov/Assets/PW/LOWWP/document+library/Los+Osos+Basin+Update+w+Exhibits+5-4-2010.pdf .

[31] Cleath and Associates. 2006. Los Osos Upper Aquifer Water Quality Characterization. Prepared for the Los Osos Community Services District. San Luis Obispo, CA, 88 pp. Accessible at:
http://www.losososcsd.org/Library/Document%20Library/UPPER%20AQUIFER%20CHARACTERIZATION.pdf

- Education and outreach campaigns to teach practices that reduce stormwater pollutants (i.e. reducing fertilizer and pesticide use, lawn watering, and car washing)
- Support of municipal programs to encourage residents, visitors, and businesses to reduce stormwater runoff and conserve water, in alignment with the County Master Water Plan
- Partnerships with local nurseries to educate the public about invasive species and promote the use of native plants that are adapted to the local water regime
- Education and outreach programs to encourage reduced water use in the home
- Support of municipal, county, and state efforts to incentivize low impact development and other stormwater management measures taken by individual property owners and businesses
- Development and support of demonstration projects that implement low impact development techniques, such as rainwater gardens, green streets, and other on-site infiltration practices

See also action plans FWR-5 and FWR-6 in the Freshwater Resources section. These action plans also address water conservation.

Partners: City of Morro Bay, County of SLO, LOCSD, Water Board, and local residents, property owners and business operators

Timeframe: Ongoing

Cost: $-$$

Implementation Tracking: BMP educational materials – number distributed and/or persons reached through different media. Number of BMP projects implemented in each municipality. Reduced amounts of various pollutants in tested stormwater samples. Reductions in domestic water use, as relevant to municipal partner efforts.

BMP-6 Support methods to reduce pet waste entering creeks and the bay through storm runoff. *(Related 2001 action: BACT-8)* ★

The population of household pets is generally much higher in urban areas. The American Veterinary Medical Association estimates that nearly 70% of households nationwide have either a dog or cat as a pet, and many households have more than one pet[32]. While pets enhance our lives and communities, their waste contributes bacterial contamination to the estuary. The Estuary Program has supported efforts to reduce pet waste, principally by coordinating and helping fund the placement of "Mutt Mitt" dispensers at locations popular with dog walkers. The Mutt Mitt program is extremely popular in the community and offers an opportunity to volunteer with or donate to the Estuary Program. The Estuary Program also supports appropriately located and maintained off-leash dog parks. The Estuary Program has partnered with other groups to educate pet owners about the deleterious effects of pet waste and ways to better control and dispose of such waste. Activities that may be undertaken to support this action plan include

- Continuation of the Mutt Mitts program and management of volunteers to support it
- Outreach materials and partnership efforts to educate pet owners about proper waste disposal
- Support for additional off-leash dog parks appropriately located and maintained

Partners: City of Morro Bay, County of SLO and LOCSD

Timeframe: Mutt mitts and education are ongoing; dog parks are contingent on local government action.

Cost: $

Implementation Tracking: Number of mutt mitts dispensed and dispensers maintained. Number of educational materials distributed and/or persons reached. Amount of volunteer time and funding donated to support Mutt Mitt program.

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[32] American Veterinary Medical Association. 2007. U.S. Pet Ownership and Demographics Sourcebook. http://www.avma.org/reference/marketstats/ownership.asp

BMP-7 Support the implementation of Best Management Practices by local governments related to storm water pollution prevention. *(Related 2001 actions: SED-1, CC-2, CC-4)* ★

Pursuant the Clean Water Act and National Pollution Discharge Elimination System (NPDES) requirements, local governments must prepare Storm Water Pollution Prevention Plans (SWPPPs). The Estuary Program supports the development and implementation of SWPPPs by the City of Morro Bay, and the County of San Luis Obispo in conjunction with the LOCSD. SWPPPs typically include provisions to limit storm water pollution from construction and maintenance activities; educational programs to encourage pollution reduction measures by the agency employees and area residents; and upgrades to storm water collection systems, among other measures. In addition to the SWPPP requirement, local municipalities have emphasized the need for ongoing training so that storm water managers, as well as consulting engineers, remain current with evolving practices and technology. Trainings and a resource library that consolidates water quality data, implementation effectiveness studies, and up-to-date practices may be important tools for this effort.

Another area of possible collaboration among the local agencies, supported by the Estuary Program, is the development of regional priorities among storm water pollution reduction programs. All regional priorities should be informed by SWPPPs, current regulatory requirements, and stormwater environmental issues of greatest concern.

Support to local governments for implementing BMPs related to low impact development is available through the Low Impact Development Initiative (LIDI). LIDI provides assistance for the design of specific projects that minimize storm water impacts and in the development of appropriate policies and standards. The Bay Foundation, the non-profit umbrella organization for the Estuary Program, provides administrative and staff support to LIDI. See USE-5 for additional information and activities related to this action plan.

Activities to help implement this action plan may include

- Support for training events and programs to increase the technical capacity of local agencies in meeting stormwater permit requirements
- Support for municipalities in meeting education and outreach requirements in stormwater permits
- Facilitation of increased collaboration between LIDI and Morro Bay watershed communities
- Facilitation of the development of regional stormwater priorities that support local pollution reduction programs and regulations
- Support for increasing access to reports and methodologies explaining successful approaches to pollution reduction

Partners: Water Board, City of Morro Bay, County of SLO, LOCSD, LIDI, CSLRCD, SLO Green Build

Timeframe: Ongoing.

Cost: $ - $$$

Costs will vary with the nature of particular projects.

Implementation Tracking: Number and type of SWPPP programs put into effect. Estimates of storm water pollution reduction. Number of training or other efforts to increase local knowledge of evolving practices and technology.

BOATING AND HARBOR MANAGEMENT

Commercial and recreational boating activities are the historic essence of the Morro Bay harbor and are critical components of the local economy. Commercial fishing brings jobs and infrastructure, and a source of local fish for restaurants and residents. Recreational fishing supports local businesses that provide charter trips, boat rentals, and bait and tackle. People who come to fish in Morro Bay often spend money at local businesses. However, the operation and maintenance of vessels can generate pollution in the bay. Examples of potential pollutants include toxic cleaners and solvents, marine varnishes and anti-fouling paints, batteries, fuels, and lubricants. Furthermore, when boat operators fail to use appropriate waste disposal facilities, human waste and toxic substances often end up in the water. Marina and boating-related BMPs can reduce or prevent pollution associated with boats. Many BMPs can be conveniently carried out by boat owners and operators and are currently in use, but some BMPS require more infrastructure (such as convenient waste disposal and vessel maintenance facilities).

A related problem in Morro Bay has been illegal moorings and abandoned boats. A major effort undertaken by DFG, OSPR and DPR, with the support of the Estuary Program and local agencies, has largely eliminated illegal moorings. In addition, many neglected boats that had sunk or were in danger of doing so, have been removed by the City of Morro Bay with funding assistance from the Estuary Program. Nonetheless, in poor economic times and as the commercial fishing industry adapts to new environmental and regulatory situations, the potential for abandoned boats and illegal moorings remains. Abandoned vessels are not only potential pollution sources but can be hazards to safe navigation. The City of Morro Bay and the Estuary Program have created a strong partnership to address the numerous consequences of abandoned boats.

The boating community of the Morro Bay area is a diverse group consisting of recreational and commercial boaters who enjoy one of the most pristine bays on the California Coast. The wide variety of concerns, challenges, and viewpoints of this community must be considered when implementing BMPs and generating education materials.

BMP-8 Support the implementation of Best Management Practices related to harbor operations.
(Related 2001 actions: HMT-2, BACT-5 and EDU-2) ★

The City of Morro Bay and its Harbor Department have been strong partners of the Estuary Program and work diligently for efficient, effective, and environmentally protective harbor operations. Past partnership efforts include derelict boat removal, illegal mooring removal, and spill prevention and remediation. A variety of BMPs can be implemented at the municipal level to reduce environmental impacts from boat-related activities, and many have already been put in place. Specific activities that may be implemented or continued in the future include

- Establishing additional and maintaining existing hazardous waste disposal sites, including bayside locations near other marina facilities
- Establishing additional and maintaining existing marine sanitation pump-out stations
- Educating the boating community to encourage the use of hazardous waste and pump-out facilities
- Developing a boat haul-out and maintenance center in Morro Bay, as well as other infrastructure or equipment that support marina BMPs (see also BMP-9)
- Continuing to support the city of Morro Bay in removing, when necessary, illegal moorings and derelict and abandoned boats
- Maintaining plans, equipment and training for spill prevention and disaster preparedness

Partners: City of Morro Bay, DPR, DFG, OSPR

Timeframe: Ongoing

The timing of specific projects related to additional facilities is largely contingent on funding.

Cost: $ - $$$

Certain educational projects are relatively low cost; however, major facility upgrades and developing a boat haul-out facility are expensive undertakings and will likely proceed only with additional state or federal grant/loan support.

Implementation Tracking: Use rates of existing facilities. Facilities added or upgraded. Numbers of derelict boats removed and/or illegal moorings removed.

BMP-9 Support the implementation of Best Management Practices related to commercial and recreational boating. *(Related 2001 actions: BACT-5 and EDU-2)* ★

The Estuary Program participates in outreach programs to the boating community about best practices to reduce pollution in the bay. These BMPs focus on actions that individual boat owners can take to reduce the environmental impact of boating activities, including sailing, motor boating, fishing, and living aboard a vessel. Outreach and education efforts are most successful when coupled with the availability of adequate facilities for the boating community, as well as enforcement of existing regulations (see also BMP-8). Activities under this action plan may include training community volunteers and educating boaters about

- Proper waste disposal methods and locations
- How to address a spill
- Conducting common maintenance activities (such as paint and hull scraping and the use of toxic paints) in environmentally sensitive ways
- Avoiding the introduction of invasive species
- Observing marine mammals and birds safely and legally while recreating on the bay
- Reducing marine debris from recreational boating activities

Partners: City of Morro Bay, DPR, and boat owners

Timeframe: Ongoing

Cost: $

Outreach efforts have typically been relatively low cost; maintenance of public facilities and enforcement are much more costly for municipalities to implement.

Implementation Tracking: Outreach projects and the numbers of materials distributed and/or persons reached by various media. Use rates of existing and new facilities related to BMP implementation.

MUNICIPAL WASTEWATER TREATMENT

The variety of urban and public land uses in the Morro Bay watershed necessitate some centralized wastewater treatment to maintain estuarine, coastal, and stream water quality. Wastewater treatment plants reduce nutrients and bacteria in wastewater, as well as providing recycled water for reuse. Two wastewater treatment plants currently operate within the Morro Bay watershed – the joint City of Morro Bay/Cayucos CSD plant and the California Men's Colony (CMC) plant. The Morro Bay treatment plant is currently in the planning process for a substantial upgrade to meet its existing NPDES permit requirements. The CMC plant was last upgraded in 2007 and is planning an additional upgrade to address chlorine in discharged effluent. Los Osos currently relies primarily on septic tanks for wastewater treatment, but is moving forward with an approved and permitted wastewater treatment plant project.

BMP-10 Continue to support the implementation of a wastewater treatment facility in Los Osos consistent with permits and plans approved by the County of San Luis Obispo, Water Board, California Coastal Commission and other relevant agencies. *(Related 2001 action: NUTR-1)*

Los Osos depends almost entirely on individual septic systems to manage waste, and portions of the community are densely developed. Recognizing that this waste management approach impacts both surface waters and groundwater (used for domestic drinking water), the Water Board required the development of a wastewater treatment system to meet current water quality standards. The history of permitting of this collection and treatment facility is long and complex. After more than 20 years, the result is a planned system permitted by the County of San Luis Obispo, the Water Board and the California Coastal Commission. The County is managing the implementation of the project, including the design and construction, as well as ensuring compliance with the numerous conditions imposed by the permitting agencies. The management and operation of the system will be the responsibility of the LOCSD. The Estuary Program supports the installation of a wastewater treatment plant and supports the completion of the project to bring about positive changes in local water quality. The Estuary Program also supports careful study of the impacts and benefits of additional and future project elements to develop recycled water systems, and implementation of those systems when appropriate. The Estuary Program supporting activities may include

- Sharing relevant water quality data with the partners involved in the plant construction
- Supporting agencies in any information needs related to estuary and creek impacts from the upgrade
- Providing technical expertise for any planned monitoring efforts related to the new plant

Partners: LOCSD, County of SLO, Water Board, California Coastal Commission

Timeframe: System to be installed and operating by 2014

Cost: $-$$$$

Cost for plant construction can be quite high, but water quality monitoring costs and other support efforts can be relatively affordable.

Implementation Tracking: Estuary Program actions to support the installation of a wastewater treatment plant, including: data sharing, local water quality monitoring, research support, and facilitating the transfer of relevant knowledge between experts and implementing parties.

BMP-11 Continue to support compliance by the California Men's Colony wastewater treatment facility with permit standards required by the Central Coast Regional Water Quality Control Board. *(Related 2001 action: NUTR-2)*

Originally constructed in 1940 by the Department of the Army Corps of Engineers, CMC wastewater treatment plant is now owned and operated by the California Department of Corrections. The plant treats effluent from CMC, Cuesta College, nearby county facilities, and the Camp San Luis Obispo National Guard base. After several upgrades, the plant was rebuilt in 2007 to increase capacity, improve infrastructure, and

add oxidation ditches. It is currently designed to handle 1.3 million gallons per day (mgd) of wastewater[33]. Treated effluent is used by the County to irrigate Dairy Creek Golf Course, Cal Poly to irrigate fodder crops, and is also discharged to Chorro Creek at a minimum continuous discharge of 0.75 cubic feet per second. This facility is subject to NPDES permitting through the Water Board.

Wastewater entering the plant is first screened to remove large debris and processed to remove grit and sands. Wastewater then receives oxidation treatment and goes through a secondary clarifier, finally receiving tertiary treatment through a sand filter. Nitrified effluent is then chlorinated and dechlorinated prior to being discharged into Chorro Creek. The discharge to Chorro Creek is beneficial when it meets water quality standards because it increases flow in Chorro Creek, and provides significant flow in the creek in the summer months, thus maintaining and enhancing fishery, wildlife, recreational, and other in-stream beneficial uses. However, CMC has struggled to meet effluent permit standards due to high levels of chlorine. CMC is planning an additional upgrade to move from chlorination to UV disinfection to address this problem. Levels of emerging contaminants, such as pharmaceuticals, in the effluent are largely unknown at this time.

The Estuary Program supports CMC's efforts to upgrade the plant and discharge effluent to Chorro Creek that meets all water quality requirements from the Water Board. Supporting activities may include

- Water quality monitoring below and above the discharge site on Chorro Creek to determine water quality impacts according to the suite of indicators the Estuary Program monitors
- Data sharing to provide CMC and the Water Board with water quality information
- Implementation of projects to help improve water quality and quantity throughout Chorro Creek, including any supplemental environmental projects proposed in conjunction with CMC

Partners: CMC, Water Board

Timeframe: Timeframe is dependent on upgrade needs and water quality requirements – UV disinfection upgrade is expected to be complete in 2013. Data collection is ongoing.

Cost: $-$$$$

Plant upgrades are costly, but water quality monitoring and other support efforts can be very affordable.

Implementation Tracking: Progress toward completion of the upgrade. Number of permit violations. Demonstrated water quality changes over time.

BMP-12 Support efforts of the Central Coast Regional Water Quality Control Board, California Coastal Commission, City of Morro Bay, and the community of Cayucos to upgrade the Morro Bay/Cayucos wastewater treatment facility and related ocean outfall.

The City of Morro Bay and the community of Cayucos (as a Joint Powers Authority, or JPA) are currently working on a plan to upgrade their joint municipal wastewater treatment facility. The location and design of the upgraded plant is subject to the results of the currently ongoing (as of December 2011) California Coastal Commission permitting process. The existing plant has a capacity of 0.97 mgd when treating wastewater to full secondary treatment. Flows above 0.97 mgd receive primary treatment only. The total average dry weather flow capacity of the plant is 2.06 mgd. Primary treated effluent is mixed with secondary treated effluent before being discharged, under an NPDES permit issued by the Water Board, into the ocean through an outfall located 2,900 feet offshore[34]. Although the bay does not directly receive effluent, it is possible that

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[33] San Luis Obispo County. 2008. Technical Memorandum – Regional Treatment (Los Osos Wastewater Project Development). Accessed at: http://www.slocounty.ca.gov/Assets/PW/LOWWP/TAC/Final+Regional+Treatment+TM+website.pdf

[34] ESA Associates. 2010. Morro Bay-Cayucos Wastewater Treatment Plant Upgrade – Draft Environmental Impact Report. Accessed at: http://www.morro-bay.ca.us/documents/Public%20Services/Wastewater%20Treatment%20Plant/WWTP%20Upgrade/Morro%20Bay%20-%20Cayucos%20WWTP%20Upgrade%20DEIR.PDF

the diluted treated wastewater does occasionally enter the bay through the harbor mouth. Furthermore, the effluent may have impacts on the nearshore ocean environment and, thus, could have secondary impacts to flora and fauna using the estuary. Increasing the treatment level of the effluent could have beneficial effects to the estuary. If the plant upgrade incorporates recycled water distribution, the estuary may benefit by a reduction in the use of wells adjacent to Chorro Creek. The Estuary Program supports upgrading the plant to tertiary treatment, as approved by the California Coastal Commission, Water Board, JPA, and other relevant permitting agencies. Estuary Program supporting activities may include

- Sharing existing water quality data with the partners involved in the plant upgrade
- Supporting agencies in any information needs related to estuary and creek impacts from the upgrade
- Sharing advice for any planned monitoring efforts related to the upgrade
- Supporting the city of Morro Bay to implement recycled water re-use in an environmentally responsible manner

Partners: City of Morro Bay, Cayucos Sanitary District, California Coastal Commission, Water Board

Timeframe: The project is scheduled for installation by 2014

Cost: $-$$$$

Plant upgrades can be costly, but water quality monitoring and other support efforts can be very affordable.

Implementation Tracking: Estuary Program actions to support the installation of a wastewater treatment plant, including: data sharing, local water quality monitoring, research support, and facilitating the transfer of relevant knowledge between experts and implementers.

Ecosystem Conservation and Restoration

Morro Bay and its relatively undeveloped watershed comprise a remarkable array of habitats, including those of several rare and threatened plant and animal species. These interrelated habitats constitute an ecologically important network that supports rich biodiversity and important ecosystem functions. However, as the local population grows and land uses evolve, the watershed has experienced habitat loss and degradation and loss of critically important species. This loss in biodiversity is a priority issue for the Estuary Program. Human activities and development patterns can cause increased rates of sedimentation and pollution, as well as reduced freshwater flows, all of which impact habitats. By supporting a robust economy and high quality of life, the variety of human uses in the watershed also have great value. Some uses, like recreational activities, may help increase awareness of the value of local habitats and species. This awareness of and connection to the local environment is essential to the efforts of the Estuary Program and its partners to protect and restore habitat.

Impacts to the ecosystem of the estuary and watershed are likely to also come from predicted climate change outcomes. Altered precipitation patterns and more extreme storms events, sea level rise, increased flooding risk, and increased likelihood of fires are all predicted impacts for San Luis Obispo County.[35] These changes can have cascading effects throughout the ecosystem, which are described in more detail in the Climate Change section of this chapter.

The wide variety of habitat types found in the Morro Bay watershed are associated with the major landscape features of the estuary and the mountainous ridges of Chorro and Los Osos Valleys. These habitats include those found in freshwater and brackish wetlands, creeks and riparian corridors, and upland areas. Some habitats in Morro Bay, such as estuarine wetlands, native bunchgrass grasslands, and maritime chaparral, have largely vanished from southern and central California, or have been highly altered. The Morro Bay estuary is a rare remnant of these once abundant coastal ecosystems. To protect and restore these rare and imperiled habitats, the Estuary Program uses an ecosystem-based approach that considers the most strategic areas to protect and restore based on the ecosystem functions they provide, their connectivity to other important habitats, and the quality and sensitivity of habitat present. Although conservation work, like land acquisitions, is necessarily opportunistic, the Estuary Program strives over time to protect connected and highly functioning habitats across the watershed.

Connectivity is important to reduce population isolation, extinction, and related stresses (such as inbreeding, increased predation, and disease) and preserve biodiversity. Many species in the Morro Bay watershed require large spaces to adequately hunt and breed. When one continuous large space cannot be preserved, the best alternative is preserving wildlife corridors and transition habitats to encourage connectivity. It is also important to prioritize the protection of habitats that provide highly valued ecosystem functions, such as floodplains that help to manage flooding and sedimentation to the estuary. These types of functions are important to preserve because they help protect other habitats that benefit from those services, as well as providing human-related benefits (such as reduced flooding).

Identifying and mapping the presence of specific habitats and critical species (especially special status species that are listed as threatened, endangered, or species of concern) is the first step in protecting these resources. Past Estuary Program efforts include: a detailed wetlands mapping program in cooperation with the California Coastal Commission; upland habitat surveys conducted in the Los Osos area by the Land Conservancy of SLO; and steelhead inventories in various creeks by partner organizations. The Estuary Program supports the continued maintenance and refinement of these data sets and mapping efforts.

Once habitats and species are known, perhaps the most effective way of protecting them is through the public purchase of critical lands (see LA-1). Whether or not habitat is in public ownership, there remains a need for restoration and ongoing maintenance. Thus, the Estuary Program has been involved in a wide variety of restoration programs on both public and private lands, including creek bank repair and erosion

[35] Koopman, M.E., Meis, K. and Corbett, J. 2010. Integrated Climate Change Adaptation Planning in San Luis Obispo County. The GEOS Institute and Local Government Commission, 47 pp. Accessed at: http://www.slocounty.ca.gov/Assets/PL/CAP-LUCE/climate_change.pdf

control, riparian fencing and re-vegetation, the elimination of barriers to migrating steelhead, and dunes re-vegetation. Frequently, the Estuary Program has partnered with agencies and organizations and has provided technical expertise, funding and, in some cases, grant management. All of these restoration approaches aim to protect essential habitat, increase connectivity, and preserve or restore critical ecological functions. The action plans in this section broaden the set of restoration tools that the Estuary Program will use beyond those used in the past and incorporate the need for research and data to understand certain complex environmental processes before restoration can achieve the most desirable results.

RIPARIAN

Riparian habitats are comprised of the vegetation and physical features of stream channels, beds, banks, and floodplains. These habitats provide cover and connectivity for in-stream organisms, such as fish and invertebrates, and a variety of birds, mammals and reptiles that use the riparian corridor. Without these corridors, many animals would be unable to migrate between habitats used for grazing, hunting, and breeding.

The Estuary Program and other partners in the watershed place particular emphasis on preserving riparian habitats to help restore healthy steelhead trout populations in Chorro and Los Osos creeks. Steelhead are an important indicator species of a creek's health because they require low sediment loads, healthy riparian habitat, no migration barriers, high water quality, and adequate freshwater flow. The steelhead in the Morro Bay watershed is the South-Central California Coast distinct population segment and is listed as threatened under the Endangered Species Act. In past efforts, the Estuary Program has contributed technical and funding support for habitat restoration and other implementation projects, and has assisted with the grants application and management and ongoing monitoring of results.

ECR-1 Support the maintenance and enhancement of in-stream habitat for freshwater aquatic species, including but not limited to streambed composition, stream geomorphology, water quality, and water temperature. *(Related 2001 actions: STL-2, STL-3, and CC-5)*

High quality in-stream habitat is critical to sustaining native aquatic species, including special status species such as steelhead trout and California red-legged frogs. Sedimentation, erosion, removal of riparian vegetation, reduced freshwater flow, and increased pollution loads (including toxics and nutrient inputs) can all negatively impact in-stream habitats. The Estuary Program supports and implements projects to eliminate or reduce these impacts and restore natural geomorphology and ecological processes. Streambed restoration projects may focus on restoring a beneficial mix of cobble and gravel sizes, woody debris, overhanging banks, deep scour pools, and shallow riffle areas. Since 2001, the Estuary Program has successfully supported a variety of partners in completing restoration and enhancement projects benefiting riparian habitat. This work resulted in more than 87 miles of stream restoration and enhancement from 2006 to 2011.

One area of particular concern for steelhead trout is the presence of barriers that prevent passage to upstream habitats. A steelhead's ability to migrate upstream is critical to spawning success. Barriers to passage can be in the form of culverts, bridges, waterfalls, or debris jams. The Estuary Program has supported an assessment of existing barriers in the watershed, projects to modify some barriers, and the development of plans for additional barrier removal. Support from the Estuary Program has included direct funding, technical assistance, and grant management. An important issue for further barrier removal has been the presence of the invasive Sacramento pikeminnow that preys on young steelhead and can compete with steelhead for habitat and resources. The Estuary Program has supported research to determine whether or not barrier removal would facilitate the spread of this invasive species. Preliminary results indicate that the pikeminnow's preferred habitat is the warmer waters of the main creek stems, rather than the fast flowing, cold waters of the upper tributaries that the steelhead prefer. These results demonstrate the low risk of an increase in the pikeminnow population and range when removing barriers to steelhead habitat.

Estuary Program activities to implement this action plan may include

- Re-vegetation of riparian corridors
- Reduction of erosion and prevention of other habitat impacts through riparian fencing to deter grazing animals from entering streams
- Reduction of nutrient inputs through BMPs on agricultural fields
- Removal or modification of migration barriers
- Restoration of natural stream geomorphologic patterns
- Implementation of water conservation projects to help maintain flow in streams (see also FWR-5)
- Mapping and removal of invasive species in riparian habitats (see also ECR-16)

Partners: USFWS, NOAA NMFS, DFG, CSLRCD, Cal Poly, Land Conservancy of SLO, the County of SLO, California State Coastal Conservancy and private property owners.

Timeframe: Ongoing.

Cost: $$-$$$$

Implementation Tracking: Stream miles restored by specific projects (i.e. re-vegetation, fenced, natural streambed restored, etc.). The number of steelhead barriers removed. Monitoring status of specific projects.

ECR-2 Support the maintenance and enhancement of riparian corridors and native riparian vegetation and the implementation of projects to advance bank stabilization, floodplain restoration, and stream geomorphology restoration. *(Related 2001 actions: STL-4 and SED-5)*

Well vegetated and complex riparian corridors are an important component in the healthy habitat of steelhead trout and other riparian species. Vegetated riparian corridors maintain bank stability, provide shade for the creek channel, and provide a food base for diverse insect fauna. They also are an extremely important resource for terrestrial animals and birds that use this type of habitat for migration corridors, breeding habitat, and foraging grounds.

Riparian corridors can be degraded through a number of human activities, including over grazing, vegetation removal, and development near creek beds. Since 2001, the Estuary Program has successfully supported a variety of partners in restoring and enhancing riparian areas. These efforts have resulted in 87 miles of creek with restored or enhanced riparian corridors. The Estuary Program will continue to support the enhancement and restoration of riparian corridors. Support activities may include

- Implementing riparian restoration projects, such as re-vegetation, bank stabilization, and riparian fencing
- Providing technical assistance and/or funding to support similar projects by private landowners or other partners
- Supporting partners in securing and managing outsides funds to complete restoration projects

Partners: USFWS, NOAA NMFS, DFG, CSLRCD, Cal Poly, Land Conservancy of SLO, the County of SLO, Fish America Foundation, California State Coastal Conservancy, NRCS, UCCE, and private property owners.

Timeframe: Ongoing.

Cost: $$ - $$$

Costs vary widely with the size and scope of projects; for example, establishing setbacks with exclusionary fencing can be relatively low cost while major bank stabilization projects can be very expensive.

Implementation Tracking: Miles of riparian corridor enhanced and/or restored. Miles of exclusionary fencing installed. Number of landowners involved in riparian enhancement projects.

WETLANDS

Wetland habitats are increasingly rare around the world, and particularly so in coastal California. More than 90 percent of California's historic coastal wetlands have been lost or highly altered. Morro Bay represents one of the largest, relatively pristine and intact coastal wetlands complexes in the southern portion of the state. The wide variety of wetland habitat types found in the estuary provides critical feeding, resting, and breeding grounds for resident shorebird species and migratory birds that travel the Pacific Flyway each year.

The Pacific Flyway is one of only four major migratory routes in North America, and Morro Bay is an important stop for birds traveling south along the west coast. The protected wetlands of Morro Bay are used by nearly two hundred different bird species every winter, some of them threatened or endangered.[36] Some sensitive species that use Morro Bay include the Brown Pelican, American Peregrine Falcon, Black Brant, Western Snowy Plover, and Marbled Murrelet.[37]

Tidal mudflats, tidal marshes, seasonal wetlands, and freshwater marshes compose the diverse wetland habitats in Morro Bay. These habitats are characterized by unique salinity and tidal influences and their vegetation communities vary widely as a result. Some sensitive plant species inhabit the Morro Bay wetlands, including Marsh Sandwort, California Seablite, and Salt Marsh Bird's-Beak. In addition to providing bird habitat, wetlands (mudflats and tidal marshes in particular) serve as nursery and foraging grounds for steelhead trout, tidewater gobies, and a variety of small mammals and estuarine fishes.

In additional to providing indispensable habitat, wetlands serve important ecological functions by filtering nitrogen, phosphorous, and other pollutants out of water entering the estuary from streams, and providing flood protection. Wetlands also store carbon in plant mass (reducing carbon dioxide in the atmosphere) and protect shorelines from erosion. These functions can be reduced or eliminated entirely when wetlands are significantly altered by development, hydrologic changes, increased sedimentation, and high pollutant levels.

ECR-3 Promote wetlands protection and enhancement by supporting appropriate regulatory standards and by encouraging effective management. *(Related 2001 actions: HAB-6 and HAB-7)* ⦿

The important ecological functions of wetlands, and the high rate of loss across California, have driven protection and restoration efforts in Morro Bay. Many local organizations have worked toward wetland protection since the 1970's. Past restoration efforts addressed a wide variety of impacts, including increased sedimentation due to altered floodplain regimes, invasive species, and pollution sources. In the future, climate change impacts may transform wetland habitats and reduce ecological functioning. In San Luis Obispo County, sedimentation may increase in coastal estuaries, bird diversity may decrease, estuarine salinity balances may be altered, species composition of specific habitats may change, precipitation patterns will be altered, and sea level rise will occur.[38] Without diverse plant community composition and resilient hydrologic cycling, wetlands will be less effective at filtering pollutants, providing flood protection, and reducing erosion. Increased sedimentation may reduce tidal mudflats and other low-lying wetland habitats that provide important feeding and resting grounds for many species. These future conditions are hard to predict, however, as the interplay between climate change and other impacts is largely unknown.

Support for wetlands protection comes from local, regional, state, and national organizations and public agencies. The Estuary Program has worked with this broad array of partners to protect wetland habitats through land acquisition and restore habitat function through improving water quality and reducing sedimentation. The Estuary Program's future actions must also consider climate change impacts and

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[36] From Audubon Christmas Bird Count data for Morro Bay, California: http://audubon2.org/cbchist/count_table.html
[37] Sims, A.E. 2010. Atlas of sensitive species of the Morro Bay area. Morro Bay National Estuary Program, Morro Bay, California and California Department of Parks and Recreation, San Luis Obispo Coast District, San Simeon. Accessed at: http://www.mbnep.org/files/ATLAS_FINAL2_low.pdf
[38] Koopman, M.E., Meis, K and Corbett, J. 2010. Integrated Climate Change Adaptation Planning in San Luis Obispo County. The GEOS Institute and Local Government Commission, 47 pp. Accessed at: http://www.slocounty.ca.gov/Assets/PL/CAP-LUCE/climate_change.pdf

adaptation approaches. As the Estuary Program continues to work with many partners to protect wetlands, activities may include

- Appropriate land acquisitions that increase wetland protection in a comprehensive manner
- Floodplain restoration and other sediment diversion tactics
- Implementation of agricultural, ranching, and urban BMPs to reduce pollutant runoff to wetlands
- Removal of invasive species in wetland areas
- Restoration projects to return wetland habitats to sustainable hydrologic functioning and a balanced native plant and animal community
- Sharing of existing data, as relevant, to regulatory agencies for wetland protection efforts.

Partners: California Coastal Commission, California State Coastal Conservancy, TPL, DPR, DFG, USFWS, County of SLO, City of Morro Bay, and Morro Coast Audubon Society.

Timeframe: Ongoing.

Cost: $ - $$$$

Certain protection actions, such as the acquisition of shoreline wetlands, are very expensive (see LA-1).

Implementation Tracking: Acres of different wetlands habitat protected or enhanced. Monitoring data shared to support enforcement of regulations. Reductions achieved in pollutant and sediment inputs to wetland areas. Quantification of pollutant loads captured in constructed wetlands for water treatment, if applicable to project.

ECR-4 Identify the most valuable wetlands areas to provide buffer areas and transition habitats and to create functional connections between ecologically important areas. *(Related 2001 action: HAB-3)* ⦿

Transition habitats are dynamic zones that allow migration of organisms and movement of nutrients and energy between established habitats. These valuable zones connect habitats that provide integrated functions within an ecosystem.[39] Buffer areas are transitional habitats established between protected areas (such as wetlands) and other land uses, like agriculture or development. Buffers help protect important habitats by slowing or stopping the input of sediment and polluted runoff from nearby land uses. As land uses evolve in the Morro Bay watershed and wetland habitats become even more important in providing essential functions, conservation must evolve as well. Incorporating transition habitats and buffer areas into conservation plans will allow the Estuary Program and its partners to more strategically protect existing wetlands and have greater success in restoring altered wetland habitats.

A preliminary step in this more strategic conservation approach will be to identify areas that provide wetland buffers and transition habitats. In a related prior effort, the Estuary Program was a partner with the California Coastal Commission and others to comprehensively map wetlands in Morro Bay and to assemble associated data into a Geographic Information System (GIS). This action plan will expand on that work by defining appropriate buffers and transitional habitats that protect and enhance functional connections between these important habitat areas. Activities under this action plan may include

- Development of an assessment method to define buffer areas and transition habitats specific to the wetland habitats of Morro Bay
- Mapping of buffer areas and transition habitats determined to support ecological functions of wetlands
- Partnership activities to share information and help increase the amount of buffer and transitional areas protected in and around the estuary

Partners: California Coastal Commission, County of SLO, DPR, DFG, SCCWRP

[39] Wall, D., Palmer, M. and Snelgrove P. 2001. Biodiversity in Critical Transition Zones between Terrestrial, Freshwater, and Marine Soils and Sediments: Processes, Linkages, and Management Implications. Ecosystems, Vol. 4 (5), pp. 418-420.

Timeframe: A summary of wetland buffer areas could be completed by 2017

Cost: $$

Cost will depend largely on how much of the existing data can be utilized for these expanded purposes.

Implementation Tracking: Defined methodology to asses buffer areas and transition habitats. Map of buffers, transitions and connections.

ESTUARINE

The Morro Bay estuary is a classic estuary, heavily influenced by stream inputs and tidal and wave energy.[40] This mix of hydrologic factors supports a diverse range of habitats, including the wetland habitats discussed in the previous section. Other habitats include open water, tidal channels, intertidal sand and mud flats, sand dunes, and coastal dune scrub. As some of the most productive ecosystems in the world, estuaries are extremely valuable for their biodiversity, range of habitats, and diverse ecological functions. Estuaries protect nearby lands from storm surge impacts and sea level rise, and provide water filtration and erosion buffers. Along with these functions, the Morro Bay estuary also support vital commercial and recreation activities, such as fishing, shellfish harvesting, diving, kayaking, and boating.

Land uses and water-based activities can alter some of the functions the Morro Bay estuary provides. Elevated levels of nutrients and bacteria entering streams and the estuary degrade water quality and can cause cascading ecological impacts. Nutrient inputs may come from fertilizers, pet and livestock waste, or nearby septic systems. Increased sedimentation can result from altered landscapes and reduced vegetative cover and cause the estuary to fill in at an unnatural rate. While it is a natural process for estuaries to eventually fill due to sedimentation, the concern in Morro Bay is that the natural processes may be accelerating due to watershed disturbances. Sedimentation can result in the loss of intertidal mudflat and open water subtidal habitat and reduce light penetration to underwater habitats. Accumulated sediment also reduces the tidal volume of the estuary, impacting the ability of water to circulate in and out the estuary at a natural rate. This flushing process is important for maintaining ecosystem functions in the estuary.

These impacts from land uses may be exacerbated by climate change in the coming decades. In San Luis Obispo County, climate change will likely accelerate sea level rise, bring more severe storms, change precipitation patterns, increase sedimentation, and alter the distribution of plants and animals.[41] All of these changes have the potential to detrimentally impact the habitats and ecological functions of the estuary. Conservation actions should consider climate change impacts and strive to increase the resilience and adaptability of the estuary to these developments.

ECR-5 Support installation of new and help maintain existing sediment traps to reduce sediment delivery to Morro Bay. Support efforts to reduce erosion from sediment source areas, such as gullies and bank failures. *(Related 2001 action: SED-2)* ⦿

Reducing sedimentation in the bay calls for an integrated approach that uses multiple methods. The most effective, but also least centralized, method is to control erosion at its source. This method involves implementing BMPs on individual parcels that prevent sediment from entering creeks and tributaries (see BMP-1, BMP-2, and BMP-3). Another tactic is to remove sediment when it reaches the bay by dredging tidal channels. This approach was extensively analyzed in a study, partially funded through the Estuary Program, conducted by the USACOE. The study concluded that most dredging projects would be infeasible due to environmental impacts, regulatory restrictions, adverse public sentiment, and costs.[42] Dredging will likely be limited for the foreseeable future to the ongoing maintenance of navigation channels and the State Park Marina.

A third method is to capture sediment prior to its deposition in creeks or the bay using sediment traps. Traps can be implemented in key locations, like floodplains, to accumulate sediment from large portions of the watershed. There are many other approaches to capturing sediment in the watershed, and every type has

[40] Gleason, M.G., S. Newkirk, M.S. Merrifield, J. Howard, R. Cox, M. Webb, J. Koepcke, B. Stranko, B. Taylor, M.W. Beck, R. Fuller, P. Dye, D. Vander Schaff, J. Carter. 2011. A Conservation Assessment of West Coast (USA) Estuaries. The Nature Conservancy, Arlington VA, 65pp.

[41] Koopman, M.E., Meis, K. and Corbett, J. 2010. Integrated Climate Change Adaptation Planning in San Luis Obispo County. The GEOS Institute and Local Government Commission, 47 pp. Accessed at: http://www.slocounty.ca.gov/Assets/PL/CAP-LUCE/climate_change.pdf

[42] U.S. Army Corps of Engineers. 2007. Morro Bay Estuary Ecosystem Restoration – Draft Feasibility Report (F4). Morro Bay, CA. 138 pp.

environmental and economic costs and benefits that need to be evaluated on a case-by-case basis to determine feasibility for a particular site. Examples of sediment traps include

- Flood plain restoration
- Sediment capture ponds (including stock ponds)
- Buffer and/or filter strips
- Restoration of riparian vegetation
- Small traps associated with the road network at culvert inlets and along roadside ditches (see BMP-2).
- Road improvement and decommissioning work to keep sediment from moving downstream
- Re-vegetation of gullies

The Estuary Program implements sediment control and trap projects throughout the watershed and supports similar effort by key partners. For example, the Chorro Flats project, owned and managed by CSLRCD, restored a floodplain that has captured hundreds of thousands of cubic yards of sediment that would otherwise be deposited in the bay. The restoration of Walters Creek through streambed alterations, re-vegetation, and floodplain restoration was designed to decrease erosion on-site and reduce sedimentation moving downstream. On a smaller scale, the Estuary Program has funded gully repair and stock pond projects, including several through CSLRCD's Project Clearwater that worked with private land owners.

The Estuary Program will continue to support both small-scale sediment capture projects as well as the implementation of large scale floodplain restoration. Activities to implement this action plan may include

- Landowner support and technical assistance to install sediment capture ponds, buffer or filter strips, road sediment control projects, and gully repair
- Data and technical assistance for large-scale floodplain restoration projects in the watershed
- Land acquisitions strategically located to support sediment control
- Technical and monitoring support for voluntary programs that assist landowners with sediment control

Partners: DFG, CSLRCD, CCC, California State Coastal Conservancy, NRCS, County of San Luis Obispo, Cal Poly, other property owners in the watershed.

Timeframe: Ongoing.

Cost: $ - $$$$

Small-scale projects can be inexpensive while major floodplain restoration may many hundreds of thousands of dollars.

Implementation Tracking: Number of small-scale projects implemented. Estimates of sediment trapped by floodplain restoration and other measurable projects. Monitoring support provided to demonstrate project effectiveness.

ECR-6 Support better understanding of the hydrology and bathymetry of the bay, especially accretion patterns and backbay circulation patterns, in order to foster projects that could protect and enhance the ecological functions of the bay. *(Related 2001 action: SED-8)* ⦿

Hydrology and bathymetry play critical roles in maintaining the diversity of habitats, species, and ecological functions of the bay, yet are still not fully understood. As a classic estuary, the basic hydrologic dynamics of riverine and tidal input to the bay are well understood; however, there are still some questions about the relative magnitude of those inputs and how they fluctuate seasonally. Further, interactions between shallow groundwater aquifers and the estuary are only marginally understood. These freshwater-saltwater dynamics greatly affect the species composition and habitat distributions observed in the estuary, as well as the estuary's role in providing flood protection and water filtration.

The hydrology of the bay in turn carves out the bathymetry. Bathymetry measures the variation in depth of the estuary bottom. Although the major navigation channels in the bay are well-charted, many areas of the

shallower, southern portion of the bay are less well documented. Furthermore, some areas have frequently changing depth, depending on sediment accretion and tidal scour and erosion.

Depth variation determines the types of habitats and organisms that can exist in different parts of the estuary. This variation is particularly relevant to eelgrass beds, which require specific light penetration and temperature ranges in order to grow. Eelgrass beds provide important food and habitat for a broad array of estuarine inhabitants and are therefore a habitat of particular interest in the bay.

There is an imperative need to better understand the hydrologic circulation and bathymetry of the estuary to accurately determine habitat and species distributions and predict future changes. High-level knowledge of hydrologic patterns and changes in bathymetry over time, due to both natural and human-caused conditions, will require very sophisticated data collection and modeling. To support efforts to reach this advanced level of knowledge, the Estuary Program may engage in the following activities

- Sharing and supporting the collection of monitoring data that demonstrates changes in the bay related to hydrology and bathymetry
- Supporting technical studies of the bay to better understand hydrology and map bathymetry

Partners: DPR, State Lands Commission, Cal Poly including SLOSEA, NOAA NMFS, SCCWRP

Timeframe: Ongoing

Cost: $$ - $$$

Implementation Tracking: Mechanisms used to share monitoring data and collect additional data as needed; amount and type of data used. Support (through technical skills or funding) of necessary studies.

ECR- 7 Provide data and support research efforts to help protect eelgrass and other bay habitats and continue mapping efforts to document changes in the extent and distribution of eelgrass habitat.

(Related 2001 action: HAB-5) ⦿

Eelgrass beds supply fundamental food sources and habitat for the diversity of life in the estuary – wading birds, brant, fishes, rays, invertebrates, and more. Fish species diversity and biomass in eelgrass beds significantly exceeds areas where eelgrass has been lost, demonstrating the vital importance of these habitats.[43] Eelgrass also stabilizes sediments on the bay floor, reducing erosion in areas with established beds. Morro Bay supports the third largest eelgrass habitat in southern California.[44]

Worldwide decline of eelgrass beds has spiked concern about protection and restoration of this essential estuarine habitat, and jumpstarted efforts to determine and mitigate causes of disturbance.[45] In Morro Bay, mapping efforts revealed a 49% decrease in eelgrass coverage from 2007 (a recent peak year) to 2010.[46] Eelgrass decline in Morro Bay likely stems from a confluence of factors, but known impacts include increased sedimentation (which reduces light availability to the submerged plant), elevated nutrient concentrations from runoff, shading from boat moorings or piers, disturbance from dredging activities, and scarring of eelgrass beds by boat propellers.[47]

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[43] Pihl, L. S. Baden, N. Kautsky, P. Ronnback, T. Soderqvist, M. Troell, H. Wennhage. 2006. Shift in fish assemblage structure due to loss of seagrass *Zostera marina* habitats in Sweden. Estuarine, Coastal, and Shelf Science 67, 123-132.
[44] Bernstein, B. K. Merkel, B. Chesney, M. Sutula. 2011. Recommendations for a Southern California Regional Eelgrass Monitoring Program. Technical Report 639. Prepared for the National Marine Fisheries Service. Southern California Coastal Water Research Project. Costa Mesa, CA.
[45] Short, F.T. and S. Wyllie-Echeverria. 1996. Natural and human-induced disturbances of seagrass. Environmental Conservation, 23(1): 17-27.
[46] Morro Bay National Estuary Program. 2011. Morro Bay Eelgrass Report 2010. Morro Bay, CA. Accessed at: http://www.mbnep.org/files/2010%20Eelgrass%20Monitoring%20Report_FINAL.pdf
[47] Morro Bay National Estuary Program. 2011. Morro Bay Eelgrass Report 2010. Morro Bay, CA. Accessed at: http://www.mbnep.org/files/2010%20Eelgrass%20Monitoring%20Report_FINAL.pdf

Climate change will also impact eelgrass, although specific changes in distribution are difficult to predict. Changes in sedimentation and precipitation patterns may stress existing beds and sea level rise will likely alter the areas that are suitable for eelgrass beds.

Dredging uniquely impacts eelgrass in Morro Bay because navigation channels are dredged on a regular cycle to maintain maritime safety and usability. Dredging beneficially maintains tidal flushing in the bay, but the movement of sediment during the process can smother eelgrass beds. Dredging can also directly impact eelgrass beds through direct removal or by causing beds to collapse from lack of stability. The City of Morro Bay and the ACOE adhere to legal requirements for avoiding eelgrass and mitigating observed impacts. The Estuary Program provides data from regular mapping efforts to inform planning and supports monitoring efforts to track the health of beds throughout the bay. Maintaining vibrant eelgrass beds in Morro Bay is a high priority for the Estuary Program and data sharing is aimed at minimizing impacts to the maximum extent possible.

The Estuary Program will continue long-term efforts to track changes in the health of eelgrass and other bay habitats to inform management and restoration decisions. Some activities under this action plan may include

- Acquiring multispectral aerial imagery of the bay during relevant tidal and seasonal conditions
- Maintaining current classification techniques to ensure accurate mapping
- Sharing mapping data through reports and other data exchange mechanisms
- Strengthening monitoring efforts of eelgrass beds and algal communities
- Monitoring health of eelgrass beds and supporting related research efforts

Partners: ACOE, City of Morro Bay, DPR, NOAA NMFS, California Coastal Commission, private consultants, SCCWRP, DFG

Timeframe: Ongoing.

Cost: $-$$

Implementation Tracking: Completed mapping efforts on regular basis. Implementation of monitoring efforts and data sharing mechanisms used.

ECR-8 Support implementation of restoration to improve the quality and quantity of eelgrass habitat. *(Related 2001 action: HAB-8)*

The recent declines in eelgrass coverage in Morro Bay heightened concerns for the sustainability of this essential estuarine resource (see ECR-7). The precise causes of decline are difficult to pinpoint, especially considering the wide range of locations in which eelgrass beds are found in the estuary. More specific information is needed regarding causes of decline and successful restoration methods before restoration projects are undertaken. Still, the Estuary Program is committed to taking proactive steps to help protect and restore eelgrass habitat in the Morro Bay estuary, and will work toward developing a stronger understanding and a strategic approach to addressing this issue.

The Estuary Program has systematically mapped the location and evaluated the robustness of eelgrass beds on a regular basis. The Estuary Program has also supported research into how various environmental factors affect eelgrass productivity. Continued mapping and additional local studies are needed to understand the most effective restoration approaches to improve the quality and quantity of eelgrass beds in Morro Bay. Some activities that the Estuary Program may engage in to support restoration efforts include

- Analysis of long-term eelgrass mapping to inform restoration decisions
- Technical support of research efforts
- Monitoring and technical support of restoration efforts
- Restoration pilot projects

Partners: NOAA NMFS, Cal Poly including SLOSEA, City of Morro Bay, DPR, DFG, SCCWRP, Elkhorn Slough NERR

Timeframe: Ongoing

Cost: $$-$$$

Implementation Tracking: Use of monitoring and mapping data to support restoration and research efforts. Regular reporting on eelgrass progress.

ECR-9 Support regional and national efforts to promote estuarine conservation and restoration. ★

As a member of the National Estuary Program, the Estuary Program has a unique opportunity to engage with estuary conservationists and policy makers around the nation. The 28 National Estuary Programs (NEPs) that exist across the country formed the Association of National Estuary Programs (ANEP) and meet annually to share lessons learned and develop partnership opportunities. This network allows the NEPs to advance and share scientific research, practical approaches to conservation, education and outreach strategies, and organizational capacity-building. Furthermore, as one organization, the NEPs can advance national efforts to conserve and restore estuaries more effectively than they each could alone. The Estuary Program will continue its active role in ANEP and the USEPA's National Estuary Program and strengthen its other national partnerships (with entities such as the Coastal and Estuarine Research Federation and NOAA's National Estuarine Research Reserves, National Marine Sanctuaries, Fisheries, and Coastal Zone Management programs).

In addition to national-level affiliations, the Estuary Program strives to support nearby partners to leverage local conservation efforts into regional collaborations. With scarce funding and reduced capacity in many organizations, regional cooperation can vastly elevate the success of conservation efforts. The Estuary Program supports regional efforts to better conserve coastal watersheds and small coastal estuaries and wetlands through information sharing, capacity building, and leveraging funding. The Estuary Program participates in regional entities such as San Luis Obispo Steelhead Initiative, Tri-County Fish Team, SLOSEA, San Luis Obispo County Weed Management Area, Salmonid Restoration Federation, and the Central Coast California Regional Environmental Education Community (CREEC). Other strong partnerships include key state agencies, especially the California State Coastal Conservancy, California Coastal Commission, Ocean Protection Council, Department of Parks and Recreation, and Department of Fish and Game.

Future efforts to continue national and regional collaborations may include

- Membership in ANEP, Coastal and Estuarine Research Federation, and other organizations
- Attendance at national and regional meetings and conferences
- Continuation and improvement of established data sharing mechanisms between partners
- Collaborative funding applications and project implementation
- Participation on national and regional policy recommendation committees focusing on estuarine conservation and restoration priorities
- Collaboration on regional and national education and outreach efforts that are relevant to Morro Bay

Partners: ANEP, USEPA, NERRA, NOAA (including Fisheries, National Marine Sanctuaries, NERRS, and Coastal Zone Management), USFWS, California State Coastal Conservancy, California Coastal Commission, Ocean Protection Council, TNC, DPR, DFG, Land Conservancy of SLO, CSLRCD, Salmonid Restoration Federation, Tri-County Fish Team, San Luis Obispo Steelhead Initiative, San Luis Obispo County Weed Management Area, Central Coast CREEC, and other watershed organizations.

Timeframe: Ongoing.

Cost: $

Implementation Tracking: Participation in regional and national programs.

ECR-10 Better understand nutrient and bacteria dynamics of the estuary. ⦿

Freshwater inputs to Morro Bay can contain elevated levels of pollutants, primarily nutrients and pathogens. Long-term monitoring by the Estuary Program and partners documents the elevated presence of these pollutants in municipal stormwater runoff, streams, and the estuary of Morro Bay. The precise dynamics of pollutants reaching the estuary are complex due to the variable environmental conditions that influence water delivery, retention, and circulation in the bay, as well as nutrient cycling. A stronger understanding of these dynamics – upland sources, transport rates, retention time in the bay, and relations to seasonal and weather changes – will inform more effective pollution reduction measures.

Climate change impacts to the circulation and hydrology of the bay, as well as precipitation patterns, will likely alter nutrient and bacteria dynamics in the future. Although the outcomes of such changes are unknown at such a small, detailed scale, continuing to develop clear climate change predictions will aid in planning for bacteria and nutrient impacts.

Particular efforts that may help implement this action include

- Supporting bacteria source studies
- Continuing to support the development of numeric nutrient endpoint (NNE) criteria by the State Water Resources Control Board and the Southern California Coastal Water Research Project
- Maintaining monitoring of bacteria and nutrients in source waters and in the estuary to track changes over time
- Aligning monitoring and bacteria and nutrient studies with hydrologic studies of the bay (see ECR-6)
- Supporting climate change studies to better understand hydrological changes in the bay that may influence bacteria and nutrient dynamics

Partners: Cal Poly including SLOSEA, DPH, Water Board, State Water Board, SCCWRP

Timeframe: Ongoing.

Cost: $-$$

Implementation Tracking: Completion of bacteria sources studies. Continuation of monitoring with sharable results and spatial integration with hydrologic studies. Actions taken to support establishment of NNE criteria.

ECR-11 Support and implement activities to restore and conserve the balance of ecosystem functions of the estuary. ⦿ ★

Habitat restoration achieves limited results if a holistic, ecosystem-based approach is lacking. Only by striving for a balanced natural system can restoration and conservation succeed in bringing about stable and functioning habitats. The Estuary Program intends to implement this broader, more strategic focus so that the essential ecosystem functions provided by the estuary can be sustained. Ecosystem functions include physical, chemical, and biological processes that maintain the inherent stability of the ecosystem. These functions impart ecological benefits, such as suitable habitat, food sources, and nutrient cycling, but they also may provide anthropogenic advantages. For example, the estuary's ability to absorb tidal fluctuations and hydrologic changes protects nearby shoreline from flooding and erosion. Nutrient cycling and water filtration in wetlands help maintain water quality that is acceptable for human activities like boating and fishing. Focusing conservation planning on maintaining and enhancing ecosystem functions helps direct conservation efforts toward balanced ecosystem goals. Although one restoration project may address only the improvement of wetlands habitat, the project can have far reaching benefits to the estuary's ability to react to sea level rise if the project is planned with that broader purpose in mind.

Such an approach to conservation requires reliable data that can inform strategic restoration. Data needs range from water quality monitoring to species distribution mapping to community interaction information. The Estuary Program will strive to collect data in a manner that is suitable to this integrative approach, and will encourage local partners to do the same.

Climate change impacts will inevitably alter the ecosystem functions that the estuary provides. Rising sea level will change flooding and circulation patterns. Precipitation and temperature changes will influence species and habitat distributions, migration patterns, and flooding regimes. Freshwater availability may re-orient development and land uses in the watershed, changing the impacts of those human activities on the environment. Planning for these changes not only requires long-term data sets to indicate trends, but also localized modeling for the estuary.

Education and outreach activities can support successful ecosystem-based restoration efforts. Community restoration projects improve habitat while increasing awareness of local ecosystem processes and issues. Outreach may also be an important component of a restoration project on publicly used land to avoid impacts from visitors to the restoration site. Successful restoration sites can serve as important demonstration projects for partners in the watershed to observe how to implement specific techniques in other locations.

Activities to support this action plan may include

- Support of localized climate change modeling to predict impacts to estuary ecosystem functions
- Monitoring and data collection efforts, and integrated analysis, to inform strategic restoration activities
- Implementation of restoration activities to protect key habitats and maintain ecosystem functions
- Completion of community-based restoration projects
- Promotion of successful restoration projects as demonstration sites for local and regional partners

Partners: DPR, DFG, State Lands Commission, California Ocean Protection Council, California Coastal Commission, Land Conservancy of SLO, CSLRCD, TNC, California State Coastal Conservancy, NOAA, NOAA NMFS, Water Board, USEPA, USFWS, USGS, Cal Poly, Morro Coast Audubon Society, SWAP, CAPE, SLOSEA, City of Morro Bay, LOCSD, County of SLO

Timeframe: Contingent on the identification of particular projects, an evaluation of net benefits, and on availability of funding.

Cost: $$-$$$$

The cost of project identification and assessment will likely run in the range of $100,000 and actual implementation of even “simple” projects would almost certainly exceed that.

Implementation Tracking: Status of identification of potential projects; status of implementation for specific projects undertaken. Use of monitoring data and analysis to inform restoration projects. Use of climate change modeling results to inform restoration projects.

UPLAND

Above the estuary and streams of the Morro Bay watershed, a myriad of Mediterranean coastal habitats exists – coastal dune scrub, maritime chaparral, oak woodlands, and perennial grasslands. These upland habitats mold the nature of the estuary itself. All the freshwater entering the estuary runs through parts of these habitats. The geologic nature of the upper watershed influences weather and precipitation patterns that in turn impact the estuary and the organisms depending upon it. Each of the upland habitats harbors a specific array of plant and animal species, and many of these species require a combination of habitats and are endemic to the region. This interrelation between upland habitats, and between the upper watershed and the estuary below, makes conservation in this region essential.

Sources of degradation in upland habitats include introduction of invasive species, overgrazing on ranchlands, residential and agricultural development, and outdoor recreation. The Morro Bay watershed also encompasses some unique land uses in upland habitat areas, including higher education facilities (Cal Poly and Cuesta College), a California state prison, and a California National Guard base. Each of these longstanding entities has afforded varying levels of protection to different habitats and maintains some open space. The unique conservation needs of lands under each of these uses necessitate individualized approaches. The Estuary Program has a long history of maintaining strong working relationships with each of these entities to advance conservation goals.

As is true for other habitats in the watershed, upland areas will also be significantly altered by climate change. Perhaps the biggest factor in this region will be changes in precipitation patterns. Current predictions indicate hotter, drier and longer summers, more severe winter storms, and declines in freshwater availability. Such developments will change species distributions and habitat compositions and may cause range reductions of some habitats. Predicting the consequences of such changes is exceedingly difficult, but increasing adaptability and resilience in natural systems may help mitigate the impacts.

ECR-12 Support conservation and restoration of ecologically significant upland habitats, including but not limited to dunes scrub, maritime chaparral, oak woodlands, and native perennial grasslands and support their preservation and enhancement. *(Related 2001 action: HAB-2)* ★ ◉

Morro Bay and its watershed support a wide array of important, and in some cases very rare, habitat types. Among the rarest types include the coastal dunes complexes and maritime chaparral. These habitats support numerous special status species and important ecological functions. Conservation of these lands must incorporate climate change impacts and current and future land uses.

The Estuary Program may engage in activities such as the following to conserve upland habitats

- Targeted land acquisitions (see LA-1)
- Conservation easements and other tools to limit urban development in the upper watershed
- Assisting with implementation of relevant species recovery plans (see ECR-14)
- Educating the community about upland habitats and how to enjoy them without harming them
- Conducting monitoring to identify significant habitats and their level of impairment

Partners: County of San Luis Obispo, City of Morro Bay, LOCSD, Morro Coast Audubon Society, SWAP, DFG, DPR, California Native Plant Society, California Coastal Commission, California State Coastal Conservancy, Wildlife Conservation Board, USFWS, Land Conservancy of SLO, TPL, TNC, CCC

Timeframe: Ongoing.

Cost: $ - $$$$

Costs vary widely with the particular project; certain regulatory and educational programs are relatively low cost while land acquisitions often well exceed $1.0 million.

Implementation Tracking: Acres of different upland habitats protected or restored. Education and outreach activities implemented.

SPECIAL STATUS SPECIES AND RECOVERY PLANS

State and federal regulations protect specific species due to concerns about the viability of their populations and habitats. These species may serve as indicators for the health of a habitat or ecosystem, or may even play the role of keystone species. Keystone species are essential to maintaining the balance of an ecosystem or habitats, and often impact their habitat in way that is disproportionate relative to their abundance. Special status species play an important role in conservation because requirements to preserve their habitat often facilitate conservation and restoration activities.

Federally listed species are covered by the Endangered Species Act, and can be listed as threatened or endangered. The federal Marine Mammal Protection Act also affords particular protections to marine mammals. "Endangered" means a species is in danger of extinction throughout all or a significant portion of its range. "Threatened" means a species is likely to become endangered within the foreseeable future. In California, species can also be listed as endangered or threatened under the California Endangered Species Act. California also lists "species of concern" and "taxa to watch", as well as "sensitive species" that require special protection. These designations stem from executive regulations, rather than legislation. Furthermore, many national and international conservation organizations, such as National Audubon Society, International Union for Conservation of Nature, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora, maintain lists of species at varying levels of concern. These designations on these lists are usually supported by scientific research and monitoring.

The Endangered Species Act requires the development and implementation of approved recovery plans for all listed species. These plans aim to protect and expand habitat and may include site-specific actions to improve the species' populations enough to be de-listed.

ECR-13 Develop a better shared understanding of population dynamics of special status species populations in the estuary and watershed. *(Related 2001 action: HAB-1)* ★

Protecting special status species in the Morro Bay area depends on sound science, especially the specific understanding of how populations are affected by environmental and land use changes in the local context. This knowledge is essential to formulating viable protection and enhancement strategies and implementing recovery plans. A strong dataset of the locations and abundance of special status species is also valuable to local managers and regulators who need to meet requirements for the protection of these species, including mitigation of adverse impacts, when permitting or implementing various land uses.

An important step in developing a better shared understanding of these populations involves inventorying the distribution and numbers of special species and their habitats. The Estuary Program has helped implement extensive mapping and data collection efforts throughout the Morro Bay region. For example, staff and volunteers have mapped the location of eelgrass beds in the bay. The Estuary Program also helped fund upland habitat mapping around Los Osos. The Estuary Program also funded an atlas of species status species in Morro Bay, developed in partnership with the San Luis Obispo Coast District of California State Parks. In addition, the Estuary Program implements and supports education and outreach projects that increase public awareness of special status species and how to best protect them. An example of such an effort is the Estuary Program's support of the Montaña de Oro State Park's monitoring and education effort to protect the threatened Western Snowy Plover.

Activities to strengthen a collective understanding of special status species populations may include

- Refinement and improvement of existing special status species mapping datasets
- Support for collaborative groups that share knowledge about species status species, such as the San Luis Obispo Steelhead Initiative or the Invasive Species Action Network (see ECR-16)
- Sharing of technical knowledge and data to support studies of special status species populations
- Technical and data support for municipalities and regulators enforcing the protection of local species status species
- Education and outreach efforts to increase awareness of special status species on publicly accessible land, and to encourage stewardship-oriented behaviors

Partners: California Coastal Commission, Land Conservancy of SLO, DFG, USFWS, NOAA NMFS, City of Morro Bay, County of San Luis Obispo, LOCSD, CSLRCD, California Native Plant Society, San Luis Obispo Steelhead Initiative Cal Poly including SLOSEA and the Coastal Resources Institute.

Timeframe: Ongoing.

Cost: $$

Implementation Tracking: Maintenance of special status species and habitat inventories and datasets. Research projects related to population dynamics. Participation or membership in collaborative groups related to special status species recovery. Participation in data sharing partnerships with regulatory and management agencies in support of special status species conservation.

ECR-14 Support the implementation of species recovery plans, including local steelhead. *(Related 2001 HAB-4 and STL-1)* ★

The Morro Bay Estuary supports habitat for 15 federally listed species, some of them found nowhere else in the world. The federal Endangered Species Act directs the U.S. Fish and Wildlife Service (USFWS) and NOAA National Marine Fisheries Service (NMFS) to prepare recovery plans for all federally listed species for which they have responsibility. The following table contains a list of listed species found in the watershed, federal status, and stage of recovery plan development.

Species	Federal Status	Recovery Plan Status
Morro Bay kangaroo rat	endangered *	Final, 1982; under revision, 2000
Morro shoulderband snail	endangered *	Final, 1998
California sea-blite	endangered *	Public Draft, 2010
Morro manzanita	threatened *	Final, 1998
Indian Knob mountainbalm	endangered *	Final, 1998
Chorro Creek bog thistle	endangered *	Final, 1998
Least Bell's vireo	endangered	Draft, 1998
Western snowy plover	threatened	Final, 2007
California Brown Pelican	endangered – delisted	Final, 1983; Delisted November 17, 2009
American peregrine falcon	endangered – delisted	Final, 1983; Delisted August 25, 1999
Marbled Murrelet	threatened	Final, 1997
Salt marsh bird's-beak	endangered	Final, 1985
Marsh sandwort	endangered	Final, 1998
Southern sea otter	threatened	Revised Final, 2003
California red-legged frog	threatened	Final, 2002
South-Central CA steelhead trout	threatened	Draft currently in development
Tidewater goby	endangered	Final, 2005

*Endemic to the vicinity of the Morro Bay Watershed.

The Estuary Program has provided both technical and funding support for the design and implementation of recovery plans. For example, the Estuary Program provided funding and technical assistance for steelhead trout inventories and recovery work by CSLRCD, in cooperation with DFG and NOAA NMFS. In another example, the Estuary Program has helped implement recovery plans for shoulderband snail and Morro manzanita through funding and partnership support for the purchase of properties essential to the ongoing survival of these species (see LA-1). The Estuary Program will continue efforts to support the implementation of recovery plans, with actions such as

- Collaborative funding and technical assistance for species inventories and other monitoring efforts to inform recovery plans.
- Implementation of recovery plan actions – some examples include
    - Invasive species removal
    - Steelhead trout barrier removal and population assessment
    - Preservation of habitat through land acquisitions and conservation easements (see LA-1)

  - Technical support for the development of land use protections for specific species
  - Incorporation of special status species considerations into the design of restoration or BMP projects
- Outreach and education efforts to inform the public about the status of listed species and how to best protect them

Partners: Organizations responsible for the development and implementation of species recovery plans in the Morro Bay area include USFWS, NOAA NMFS, DFG, County of SLO and the LOCSD.

Timeframe: Ongoing; see table above regarding current status of different recovery plans.

Cost: $ - $$$$

Cost varies with each recovery plan; some implementation actions such as educational outreach are relatively low cost while others such as land acquisition are expensive.

Implementation Tracking: Implementation of recovery plan actions. Technical and data support provided for plan development.

ECR-15 Support the removal of barriers to steelhead migration and the enhancement and maintenance of in-stream habitat for steelhead and other aquatic species. *(Related 2001 actions: STL-1, STL-2, and STL-3)*

In the Morro Bay watershed, many obstructions to steelhead passage still exist, often related to abandoned agricultural diversions or aging road crossings. Steelhead swim up freshwater streams to spawn and their spawning habitat requirements are specific – consistent flow, high dissolved oxygen levels, gravel substrate with little fine sediment, and good general water quality. In-stream structures that prevent steelhead from swimming upstream limit available spawning habitat, thus limiting the population as a whole. The National Oceanic and Atmospheric Administration (NOAA) recognizes migration barriers as significant threats to the species' recovery from its threatened status under the Endangered Species Act.[48]

The Morro Bay watershed provides important habitat to steelhead trout, especially in the face of climate change. Access to a wide variety of coastal watersheds will provide steelhead with a range of adaptation opportunities as precipitation and temperatures patterns evolve. The South-Central California Coast steelhead that inhabit the Morro Bay watershed can live in warmer water with less than optimal dissolved oxygen levels, in comparison to other steelhead types. These unique characteristics may make the South-Central California Coast steelhead more capable of adapting to some climate change impacts. This adaptability highlights the importance of preserving this particular steelhead type. The Morro Bay estuary is also important to steelhead because it ensures year-round access for trout to swim upstream. In other locations along the southern coast, coastal bays become too dry in the summer to maintain connections to stream mouths.

The Estuary Program has supported several projects to remove barriers through direct funding, technical assistance, and grant management. An important issue has been the presence of the invasive Sacramento pikeminnow and the possibility that barrier removal would facilitate the spread of this invasive. Preliminary results indicate that the pikeminnow's preferred habitat is the warmer waters of the main creek stems, rather than the fast flowing, cold waters of the upper tributaries that the steelhead prefer (see also ECR-1).

Activities to support this action plan may include
- Technical assistance and leveraging funding for barrier removal and in-stream habitat improvements
- Implementation of barrier removal and in-stream habitat improvement projects
- Monitoring support for implemented projects and to help prioritize future projects
- Support for population studies to determine project placement and effectiveness

[48] NOAA National Marine Fisheries Service, Southwest Regional Office. 2007. Federal Recovery Outline for the Distinct Population Segment of the Central California Coast Steelhead. Long Beach, CA. Found at: http://www.swr.noaa.gov/recovery/FINAL_Steelhead_061507.pdf

Partners: USFWS, NOAA NMFS, DFG, CSLRCD, Cal Poly, Land Conservancy of SLO, the County of SLO, Fish America Foundation, Tri-County Fish Team, Central Coastal Salmon Enhancement, Trout Unlimited, California State Coastal Conservancy and private land owners.

Timeframe: Ongoing.

Cost: $$

Implementation Tracking: Miles of stream made accessible by barrier removal; status of specific projects. Miles of in-stream habitat restored or enhanced.

INVASIVE SPECIES

Invasive species are non-native plants and animals that can deteriorate natural systems, reducing biodiversity and impacting ecological functions. Many introduced for specific purposes (such as windbreaks or pest controls) are now rapidly converting native habitats into less desirable systems. One example is the introduction of veldt grass as a forage crop and erosion control – the plant is now taking over unique coastal dune scrub habitat and reducing it to monoculture grasslands with little ecological value.[49] The habitat provided to key species by dune scrub areas is badly impacted.

Invasive species also impact economic uses in the watershed. Noxious weeds such as yellow star thistle and purple start thistle reduce productivity of rangelands because cattle and other grazing animals will avoid eating them. Many invasive species, such as *Arundo donax* (giant reed) and blue gum eucalyptus, are much more flammable than native species and spread wildfires more quickly.

Climate change impacts in San Luis Obispo County, such as hotter, drier, and longer summers and altered precipitation patterns, may provide conditions that are more favorable to invasive species than native ones. In addition, exotic species that are not yet invasive may become so if climate change creates their preferred conditions. This is a serious threat because invasive species are extraordinarily difficult, and often practically impossible, to eradicate once they become established.

ECR-16 Develop, periodically update and implement an invasive species action plan for the estuary and watershed. *(Related 2001 actions: HAB-9 and HAB-10)* ★ ⦿

In 2010, the Estuary Program completed an Invasive Species Action Plan (viewable at http://www.centralcoastinvasives.com). Components of that plan include coordination, prevention, early detection, rapid response, control and management, and education and outreach. The plan calls for 26 specific actions related to the various components. The next steps will be the implementation of those specific actions.

Education and outreach is a particularly important component of the plan, as invasive species prevention requires knowledge of invasive species and how to control them. Because many invasive species originate as landscaping plants or for erosion control, it is important that local homeowners, not just landscapers and agriculturalists, understand the risks of planting an invasive species.

Hand in hand with the Invasive Species Action Plan is the Invasive Species Action Network. This network of land management and resource professionals works together to prevent, detect, and remove or control invasive species in the Morro Bay watershed. Meeting regularly, and sharing information electronically, the group has already prevented the colonization of one new invasive species. Algerian sea lavender is a landscaping plant that has invaded many estuaries in California. Its highly efficient seed dispersal mechanisms allow the plant to outcompete native sea lavender species, as well as other marsh plants. Luckily, the invasive plant was spotted early in Morro Bay State Park and steps were taken to remove it before it became established. The State Park and other members of the Invasive Species Action Network will continue to monitor the area for new specimens. This is just one example of the value of this collaborative network of dedicated professionals.

The Estuary Program will continue to implement the Invasive Species Action Plan. Activities may include

- Development and distribution of education and outreach materials about invasive species
- Management of the Invasive Species Action Network
- Technical support for landowners wishing to remove invasive species
- Continuation of efforts to map the distribution of invasive species in the watershed

[49] Jon Hall, Morro Bay National Estuary Program. 2010. Morro Bay Invasive Species Action Plan version 11-28-2010. Morro Bay, CA, 28 pp. Accessed at: http://www.centralcoastinvasives.com/centralcoastinvasives.com/Action_Plan_files/ISAP%20low%20res.pdf

Partners: DPR, Land Conservancy of SLO, SWAP, Camp San Luis, CCC, County Department of Agriculture, Morro Coast Audubon, California Native Plant Society, DFG, California Invasive Plant Council, California Invasive Species Council

Cost: $ - $$$

Certain action items, such as creating of list of local experts, are low cost, while others such as mapping "Red Alert" species and creating a rapid response network will cost considerably more.

Implementation Tracking: Status of implementation of the specific actions in the plan.

Watershed Crew

For more than a decade, the Estuary Program and the California Conservation Corps have collaborated in providing a Watershed Crew for projects in the Morro Bay watershed. This crew is composed of corps members specially trained to work on a wide variety of restoration projects. The crew provides a well-trained, low-cost labor supply that has been essential to a number of important and complex projects with several partners in the watershed. Beyond providing essential labor, the Watershed Crew also provides hands-on training for Conservation Corps members interested in careers related to habitat restoration or land management. Watershed Crew members also learn about a wide variety of watershed issues, such as water conservation and habitat impacts, that can guide important choices they make both in their personal and professional lives.

In recent years, the Watershed Crew partnership has grown to include the AmeriCorps Watershed Stewards Project. This project supports the placement of future natural resource practitioners in coastal watershed communities to promote community-based restoration and education about watershed issues. The Estuary Program is a local partner in this project.

Examples of projects undertaken with Watershed Crew assistance include

- Erosion control on Dairy Creek with Camp San Luis Obispo
- Riparian fencing along Dairy Creek with the County of San Luis Obispo
- Walters Creek riparian and floodplain restoration with Cal Poly
- Invasive species removal and erosion control with SWAP
- Invasive species removal and maintenance at Sweet Springs with Morro Coast Audubon Society
- Removal of pikeminnow from Chorro Valley water bodies with DFG and others

The assistance of the Watershed Crew has been essential for the Estuary Program, other organizations, and landowners in undertaking habitat restoration projects and installing BMPs. Maintaining this source of high quality, cost-effective and readily available labor is critical to the continued implementation of the CCMP.

CREW-1 Continue to support a Watershed Crew with the California Conservation Corps and other partners to provide planning, labor, outreach and other services in the watershed and to promote service and career learning in watershed management. *(Related 2001 action: CC-7)*

Partners: California Conservation Corps

Timeframe: Ongoing

Cost: $-$$

Annual contributions by the Estuary Program vary but have generally been under $100,000; however, the labor provided by the crew attracts other funders and has leveraged much larger amounts of money for projects from many sources.

Implementation Tracking: Continued availability of a CCC Watershed Crew. Number of hours worked annually by the Watershed Crew. Number of projects implemented with Watershed Crew assistance.

Freshwater Resources

Estuaries are defined as places where freshwater meets the sea. In Morro Bay, two sub-watersheds, Chorro and Los Osos creeks and their tributaries, provide most of the freshwater mingling with the ebb and flow of ocean tides. Additional freshwater inputs include springs and groundwater seeps, as well as stormwater runoff that enters the bay directly from both the developed and undeveloped lands adjacent to the shore. The creeks are closely linked to underlying shallow groundwater aquifers; thus, groundwater withdrawals not only affect the subsurface resources, but may impact surface creek flows as well.

The Mediterranean climate of Morro Bay shapes the highly seasonal and variable nature of freshwater flow to the estuary. Winter rains usually bring full-flowing creeks and replenish groundwater; by late summer, much of the creek system is reduced to a trickle. Winter rains also account for what is sometimes called the "flashy" nature of Morro Bay's watershed: intense storms can cause huge amounts of water to flow into the bay with volumes quickly declining. Morro Bay's annual precipitation is also quite variable. Years when rainfall is well below long term averages, as well as those when rain volumes greatly exceed those averages, occur frequently in the historic record.[50] Observations by wildlife professionals in this area suggest that many of the native species have adapted to these natural fluctuations in freshwater flow from year to year and from season to season.

The natural freshwater flow patterns have been highly altered in the Morro Bay region, both increasing and decreasing flows. The wastewater treatment plant operated by the California Men's Colony discharges treated effluent year round directly into Chorro Creek, and may account for a significant portion of dry season surface flows.[51] Local groundwater is withdrawn from the aquifer near Chorro Creek for private agricultural and municipal domestic use. The City of Morro Bay continues to operate well fields near Chorro Creek for water when its principal source, water delivered through the state system, is unavailable due to maintenance operations or reduced delivery schedules. Although the Morro Bay wells draw from the groundwater aquifer, the close connection between surface and groundwater in the system means that surface creek flow is often impacted by groundwater pumping. Los Osos and Baywood are entirely dependent on local wells. In the future, the approved wastewater treatment system in Los Osos is currently designed to include injecting freshwater into the underlying shallow aquifer in order to abate saltwater intrusion. The interaction between groundwater withdrawals and discharges back into the systems has significant impacts on the natural hydrologic cycle.

The predictions for precipitation changes in San Luis Obispo County due to climate change complicate the hydrologic picture.[52] Hotter, drier and longer summers coupled with more extreme storm events could exacerbate the flashy nature of the system. Flooding will likely be more prevalent, while groundwater infiltration may decrease with increasingly irregular winter rains. Erosion along stream banks may increase with higher velocity flows during extreme storm events. As water resources become scarcer throughout the state, use of local water resources may increase. Sea level rise may increase the likelihood of saltwater intrusion into groundwater aquifers (particularly in Los Osos), adding complexity to municipal water planning. Overall, these changes are likely to reduce freshwater flow into the estuary and make the timing of inputs more unpredictable.

The Morro Bay estuary ecosystem depends on freshwater mixing with the sea to create variable salinity levels that support the unique array of estuary wildlife and habitats. Thus, significant reductions in freshwater flow, and differences in seasonal patterns, threaten habitat and living resources. Reduced freshwater supplies also

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[50] Precipitation data accessed at Western Regional Climate Center website – monthly total precipitation (inches), Morro Bay Fire Department, Morro Bay CA. Accessed at: http://www.wrcc.dri.edu/cgi-bin/cliMONtpre.pl?camorr

[51] Central Coast Regional Water Quality Control Board. 2007. Total Maximum Daily Load for Nutrients and Dissolved Oxygen in Chorro Creek. San Luis Obispo County, CA. 47 pp. Accessed at: http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/chorro_creek/chorro_nut_proj_rpt.pdf

[52] Koopman, M.E., Meis, K. and Corbett, J. 2010. Integrated Climate Change Adaptation Planning in San Luis Obispo County. The GEOS Institute and Local Government Commission, 47 pp. Accessed at: http://www.slocounty.ca.gov/Assets/PL/CAP-LUCE/climate_change.pdf

impact a wide variety of beneficial uses, including domestic water supply, irrigated farming, recreation, and fishing. The Estuary Program has supported efforts to reduce the demand for water for irrigated farming and domestic use and efforts to better manage water resources in the area. In general, the Estuary Program works closely with local agencies and land owners to encourage conservation of the watershed's freshwater to the benefit of those users and public trust resources.

The Estuary Program has also promoted water conservation through a variety of educational projects, including its Bayside Living Guide and Estuary Nature Center. The Estuary Program actively promotes practices that encourage groundwater recharge, including floodplain and riparian restoration projects and promoting the use of permeable surfaces in the design of new development.

RESOURCE MANAGEMENT

Considering the complex influences on water resources in the watershed, managing those resources presents steep challenges. Municipal water managers must balance water demand in the community with maintaining a sustainable resource well into the future. Private landowners must avoid overdrawing their wells or extending beyond their legal water rights. Individual homeowners face rising water prices try to minimize costs by reducing water consumption. On top of all these specific needs for water, the State Water Board and the regional Water Board are tasked with protecting water quality and regulating water resources while balancing the many uses of water in the region.

These human water uses are essential to Morro Bay's coastal communities; however, they must be balanced with the needs of the environment to ensure viable communities well into the future. Only with healthy coastal habitats providing important ecological functions can the Morro Bay watershed maintain its unique heritage and way of life. Maintaining adequate freshwater flows for natural resources stretches current scientific knowledge to the limit of what is known. A better understanding of the interaction between water availability and specific resources is needed, as well as more sophisticated modeling showing the impact of changes to natural water regimes on habitats and species.

FWR-1 Support efforts by the State, local governments, and water purveyors to manage freshwater resources so as to provide for water users but not impair public trust resources. *(Related 2001 action: FLOW-4)*

Freshwater resources in the Morro Bay watershed are managed by a wide variety of entities – state agencies, municipalities, private water purveyors, and landowners. Los Osos water management is shared by state agencies (State Water Board, Water Board, and DPR), San Luis Obispo County, LOCSD, and private water companies. These groups are developing a comprehensive water management program for the Los Osos water basin. The underlying framework for this program is the County Master Water Plan (currently under revision) and the Los Osos Basin Management Plan (being developed by LOCSD and private water purveyors through a court agreement). The court agreement directing the basin plan development and the relevant regulations require that human uses be balanced with environmental water needs. However, achieving this balance commands high quality data demonstrating environmental water demand.

The State Water Board issues permits and licenses to use surface waters for reasonable and beneficial uses. The regional Water Board issues permits and enforces regulations related to water quality issues, including discharge to water bodies. California does not have a permit process for extracting groundwater, although in many basins court decrees have adjudicated rights to specific users. In the Chorro Valley, surface water extraction and discharge activities can influence water quality, and cause some overlap in these permit processes. For the city of Morro Bay, water resources are managed by Public Services Department. The city holds a permit from the State Water Board to extract water from wells in Chorro and Morro Valley and receives water from the State Water Project (water piped in from outside the watershed). Morro Bay also runs a desalinization plant that may provide a more consistent source of additional freshwater in the future. Other water uses in Chorro Valley are managed by the County and regulated by the State Water Board and the Regional Water Board, with the goal of balancing extraction with maintaining regulatory flow rates in Chorro Creek. These water users include Cal Poly, Camp SLO, Cuesta College, Dairy Creek Golf Course, and CMC. CMC and Cuesta College receive water from the State Water Project. This water supply is supplemented by the Chorro Reservoir (located just above CMC on Camp SLO property); a water treatment plant provides potable water from the reservoir to CMC, Camp SLO, Cuesta College, and nearby county facilities. CMC provides recycled water from its wastewater treatment plan to the Dairy Creek Golf Course for irrigation purposes. Recycled water from CMC is used to provide a minimum flow of 0.75 cfs (cubic feet per second) in Chorro Creek (see also BMP-11).

Water resources in the community of Los Osos center on groundwater basin use, which is currently undergoing an Interlocutory Stipulated Judgment to develop a basin management plan (see also FWR-2).[53]

The Estuary Program supports these collaborative management efforts and encourages water management planning that provides for continued beneficial uses while maintaining adequate flow to riparian and estuarine ecosystems. Supporting activities might include

- Facilitate collaborative planning by bringing stakeholders together on water conservation and planning projects
- Support research to provide better water use modeling and quantification in the watershed
- Support research and monitoring to bolster scientific information on environmental water demand
- Provide technical support for planning efforts
- Support for infrastructure installation and/or improvements for flow monitoring and management
- Support efforts to develop a County wide Integrated Regional Water Management Plan and maintain a current and robust Master Water Plan

Partners: State Water Board, Water Board, County of SLO, LOCSD, City of Morro Bay, CMC, DFG, private water companies, and land owners and water users in the watershed.

Timeframe: Ongoing.

Cost: $-$$$

Technical support can be low cost, but research studies and analyses of water use and environmental needs are often fairly expensive.

Implementation Tracking: Number of collaborative water conservation projects; amount of water conserved. Research and technical studies supported. Projects planned and developed by partners for water conservation planning and evaluation of water use. Monitoring data collected and shared. Number of flow monitoring sites.

FWR-2 Improve the scientific information needed to better manage freshwater resources in the watershed in order to maintain adequate flows for public trust resources.

The freshwater systems in the Morro Bay area are complex, with watersheds, sub-watersheds, aquifers with direct connections to surface waters, the presence of aquitards (layer of low permeability that interrupts the connection between surface and groundwater), and the pressure of sea water intrusion into Los Osos groundwater. Effective management approaches that recognize the needs of public trust resources cannot be developed without more sophisticated hydrologic data. Water resource managers and stakeholders need better information about future surface and creek flow changes due to climate change and water extraction, the connections between groundwater and surface water, and risks of salt water intrusion. Ultimately, a stronger scientific basis for minimum flows to support public trust resources, including steelhead, must be achieved to inform effective management (see FWR-3).

The Estuary Program has already taken steps to increase the quality and quantity of relevant scientific information available. In 2011, the program initiated a partnership project with LOCSD, private water purveyors, and the USEPA to develop a model of climate change impacts on groundwater availability in Los Osos. The Volunteer Monitoring Program continues to collect flow data at many creek sites throughout the watershed. A technical workshop, attended by local water managers and resource experts, was held during the development of this CCMP and focused in part on data needed to determine environmental water needs. Other activities that the Estuary Program may engage in to improve the scientific information available to water managers include

- Review of relevant existing literature and scientific information specific to the Morro Bay watershed

[53] LaCaro, D. 2011. Memorandum; Update on the Los Osos Groundwater Basin ISJ Working Group's Activities, San Luis Obispo County. San Luis Obispo, CA. 5 pp. Accessed at: http://www.swrcb.ca.gov/centralcoast/water_issues/hot_topics/2011_12_09_%20isj_memo.pdf.pdf

- Technical support and leveraged funding for appropriate scientific studies and monitoring efforts
- Continuation of stream flow monitoring
- Support of the maintenance and expansion of the SLO County Flood Control and Water Resources Stream gauging and rainfall network
- Support efforts to maintain the County Master Water Plan with high quality and spatially explicit data
- Facilitation of projects that engage multiple stakeholders and increase scientific knowledge of local freshwater resources

Partners: State Water Board, Water Board, County of San Luis Obispo, LOCSD, private water companies, City of Morro Bay, Cal Poly, CMC.

Timeframe: Ongoing.

Cost: $ - $$$

The cost of research projects will vary widely and certain large-scale studies are likely to be expensive. Funding from a variety of sources will be necessary.

Implementation Tracking: The number and scope of research and partner projects undertaken. Discharge monitoring data collected and shared. Maintenance or expansion of County Gauging stations, if County pursues such efforts. Additional weather station data or other scientific data sources becoming available for local landowners and resource managers.

FWR-3 Support efforts to increase understanding of freshwater flow needs for public trust resources, including supporting the development and implementation of environmental demand and minimum flow requirements. ⦿

High quality, freshwater flow sustains diverse wildlife in the estuary and the creeks that feed it. Steelhead trout rely on fast flowing waters as spawning habitat. Riparian vegetation, like willows and oaks, needs a consistent water source. Estuarine species, such as tidewater gobies and salt marsh plants, require a variable mix of fresh and saline water. Despite understanding these needs, little information exists on the precise freshwater flow required to sustain these public trust resources. Public trust resources are natural and cultural resources that are held in trust for all people and are protected under the law so they will be present for future generations. In Morro Bay, wildlife, essential habitats, commercially important species (such as steelhead trout), and navigable waters may all be considered public trust resources. This special distinction emphasizes the importance of ensuring that these resources have the freshwater flow they need while also considering the context of other important water uses.

Current minimum flow rates set by various legal agreements and water use permits rely on generalized analyses not specific to conditions and species in Morro Bay. Participants in current and future management efforts will need to have better information about these resources to properly account for them in water management agreements. Important information may include: detailed habitat data, historical flow records (considering different uses being implemented over time), characterization of catchment hydrology, data showing the effects of specific discharge rates on in-stream habitats, and water depths required for specific species.[54] At the most sophisticated level, modeling results can be used to determine the flow available for in-stream habitat under different regimes. Minimum flow requirements should also consider the future effects of climate change on freshwater availability to the system as a whole (see discussion at the beginning of the Freshwater Resources section). The Estuary Program recognizes that minimum flow requirements are an important management tool but may not always meet the full suite of needs for particular species or habitats. Conservation actions taken by the Estuary Program will also incorporate a full, ecosystem-based view of freshwater needs.

[54] Tharme, R.E. 2003. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. River Research and Applications, 19: 391-441.

The Estuary Program supports the development of a stronger collective understanding of freshwater flow needs for public trust resources. Some activities to address this action plan might include

- Technical support and leveraged funding for data collection efforts to inform minimum flow calculations and modeling
- Technical support for minimum flow planning efforts in conjunction with regulatory and municipal planning and species recovery plans
- Habitat and species population dynamics studies to inform minimum flow calculations and modeling

Partners: State Water Board, Water Board, County of San Luis Obispo, LOCSD, City of Morro Bay, Cal Poly, Central Coast Salmon Enhancement, Trout Unlimited, CCC, CMC, Camp SLO, SLO Farm Bureau, NRCS, NOAA NMFS

Timeframe: Ongoing

Cost: $$$

The cost of this type of research undertaking is likely to exceed $100,000; funding from various sources will need to be explored.

Implementation Tracking: Completion of relevant data collection efforts.

FWR-4 Encourage the re-formation of the Chorro Valley Water Users Group, or similar cooperative, to better coordinate and manage water resources in that watershed. *(Related 2001 action: FLOW-2)*

Some of the principal water users in the Chorro Valley are public agencies – Cal Poly, Cuesta College, San Luis Obispo County, California Men's Colony, the City of Morro Bay, and Camp San Luis Obispo (California National Guard, California Department of the Military). In addition, a number of private landowners rely on water from Chorro Creek and its tributaries for the water they drink and to run ranching and agricultural operations. Balancing the needs of all of these water users to achieve sustainability requires collaboration and coordination. In the past, these agencies and private interests met regularly to coordinate and manage water resources. More recently, the group has been inactive. Attentive management of water resources in the Chorro Valley must occur on a watershed scale and reconstitution of this group would be beneficial.

The Estuary Program supports collaborative solutions to water management issues and encourages such an approach in the Chorro Valley. Supporting activities may include

- Facilitation of meeting planning and preparation for the water users group
- Analysis of existing water usage, flow, and habitat data to inform group discussions
- Technical support in implementing any actions that arise from group discussions

Partners: Cal Poly, Cuesta College, CMC, City of Morro Bay, Camp SLO, County of SLO and representatives of private water users.

Timeframe: Re-establish a group by 2016; ongoing coordination thereafter.

Cost: $

Implementation Tracking: Progress toward re-establishing a water users group. Number of meetings held. Actions taken as results of the Users Group collaboration.

WATER CONSERVATION AND RE-USE

Even with well-developed and precise water management and planning, water conservation is undeniably crucial. California faces increasing demands on water coupled with diminishing supply. Although the population in the city of Morro Bay is not expected to grow rapidly over the next 25 years (less than 1% growth rate)[55], Los Osos may grow as much as 35% over the next 25 years.[56] More people mean more water demand. Climate change means a less reliable water supply. The two most productive actions that communities can take to combat these two forces is water conservation and recycled water (i.e. water re-use).

FWR-5 Support efforts to enhance water conservation and re-use throughout the watershed among institutional, agricultural, and domestic users. *(Related 2001 action: FLOW-3)* ★

Conserving water and recycling treated wastewater reduces the demand for scarce freshwater resources. Although some water conservation measures may be regulatory (like requiring low flush toilets in new construction), many measures are not well suited to regulations or would be difficult to enforce. Voluntary incentive programs and education and outreach campaigns can be more effective for some measures. The Estuary Program has collaborated with local public agencies and water purveyors to encourage water conservation among domestic users through education and outreach. In future efforts, key institutional and large-scale agricultural users should also be considered target audiences.

Examples of domestic water conservation measures include: appropriate timing and frequency of landscape watering; use of native plants to reduce landscape watering needs; installation of low flow shower heads and faucets; replacement of dishwashers and clothes washers with more efficient models; and use of low-water irrigation techniques. Within municipalities, low impact development streets and parks can increase water infiltration and decrease the need for municipal landscaping watering; installation of rainwater catchment and greywater projects can also reduce water needs for landscaping.

Water recycling requires tertiary wastewater processing to convert wastewater into water that is usable for specified purposes, such agriculture and landscaping irrigation. There are two major opportunities to explore the costs and benefits of recycled water in the Morro Bay watershed – the installation of the Los Osos wastewater treatment plant and the upgrade of the Morro Bay/Cayucos wastewater treatment plant (see BMP-10 and BMP-12). There are both costs and benefits to recycled water distribution and use at the scale of community wastewater treatment plants. The processing of the wastewater into usable water can be very expensive and the current market value for the resulting water, which has limited applications, may not cover the costs or provide a large enough profit margin to be viable. However, there are also cost and environmental benefits in reducing the need for groundwater withdrawals or purchase of additional water through the State Water Project.

The Estuary Program will participate in and support interagency collaborations to reduce groundwater withdrawals and develop recycled water distribution as appropriate. Some activities the Estuary Program might engage in to support water conservation and recycling include

- Education and outreach materials and events to encourage water conservation by domestic users
- Education and outreach materials and collaborative incentive programs to encourage water conservation by institutional and agricultural users
- Collaborative efforts with the city of Morro Bay and LOCSD to encourage water conservation
- Support for the development of incentive programs to use water conservation practices, low impact development, and new technologies or techniques
- Demonstration projects that implement rainwater catchment and other water conservation measures on individual properties and what the benefits of these projects can be

[55] City of Morro Bay. 2010 Urban Water Management Plan. Morro Bay, CA. Accessed at: http://www.morro-bay.ca.us/documents/Public%20Services/Water%20Division/MorroBay_2010_UWMP%20final.PDF
[56] Maddaus Water Management. 2011. 2011 Water Demand Analysis and Water Conservation Evaluation – Administrative Review Draft. Los Osos CA, 67 pp. Accessed at: http://www.losososcsd.org/Library/Document%20Library/DemandandConservationReport.pdf

- Technical support for municipalities in determining the applicability of recycled water and implementing water re-use plans (including Integrated Regional Water Management Plan and the County Master Water Plan)

Partners: County of San Luis Obispo, City of Morro Bay, LOCSD, private water purveyors, major private and institutional water users in the watershed, SLO Green Build, Low Impact Development Initiative, CSLRCD, San Luis Obispo Steelhead Initiative, California State Coastal Conservancy, Trout Unlimited

Timeframe: Ongoing

Cost: $

Implementation Tracking: The number and scope of water conservation/re-use programs. Gallons of water captured and potentially re-used in rainwater harvest efforts. Number of education materials and events completed. Number of demonstration projects completed. Measurable reductions in water use at appropriate scales (individual landowner or municipality-wide, depending on the project). Completed of recycled water planning and assessment studies by relevant partners.

FWR-6 Encourage well-managed groundwater recharge through a variety of means, including encouraging permeable surfaces in land use development, storm water controls, and floodplain restoration. *(Related 2001 action: FLOW-1)* ★

The climate of Morro Bay has distinct wet and dry seasons, with heavy winter storms sometimes bringing high intensity precipitation events that generate large amounts of runoff. Slowing the flow of runoff increases recharge of groundwater aquifers by allowing the water time to percolate through the ground. Limiting the amount of impervious surfaces created through development has a similar effect on groundwater recharge. There are many practical approaches that encourage infiltration. Green streets and pervious pavement reduce impervious surfaces, as do land use plans that encourage dense urban centers surrounded by open space.[57] Bioretention practices, such as bioswales, vegetated street buffers, rain gardens, tree preservation, and rooftop gardens, help keep water on-site so it has time to percolate.[58] In addition, rain barrels and cisterns collect water and store it on-site for landscaping and other uses, reducing both runoff and water demand from municipal supplies.

Besides encouraging recharge through rainfall retention, resource managers in the watershed can actively recharge water basins by injecting treated wastewater into the ground. The approved wastewater treatment system in Los Osos includes such a program to help restore groundwater volumes and retard sea water intrusion into the aquifer. There are many costs and benefits associated with this approach and the Estuary Program encourages monitoring and data analysis to track the impacts, both positive and negative, of any recharge plan that is implemented.

Activities that may support this action include

- Education and outreach materials and events to educate homeowners and local governments about effective low impact development techniques
- Collaborative efforts with other organizations encouraging low impact development
- Demonstration projects to show how to implement low impact development techniques
- Support for local municipalities in implementing low impact development as part of their land use planning and stormwater permitting

Partners: Public and private landowners, City of Morro Bay, County of SLO, LOCSD, CSLRCD, private water purveyors, LIDI, SLO Green Build

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[57] Smart Growth for Coastal and Waterfront Communities. Prepared by NOAA, EPA, ICMA, and Sea Grant. Accessed at: http://coastalsmartgrowth.noaa.gov/smartgrowth_fullreport.pdf

[58] San Luis Obispo Coalition of Appropriate Technology. 2010. San Luis Obispo Homeowner's Guide to Rainwater Management for Low Impact Development. San Luis Obispo, CA. 36 pp. Accessed at: http://www.mbnep.org/Library/Files/20101117LIDguide.pdf

Timeframe: Ongoing

Cost: $ - $$$$

Costs vary with the technique. Low impact development that utilizes more permeable surfaces is generally not significantly more costly than other approaches; the costs of larger scale storm water controls and floodplain restoration projects vary with type and scale. The wastewater injection program is part of the larger treatment system and will be funded by the LOCSD through ratepayers.

Implementation Tracking: The number, type and scale of projects. Gallons of water retained in catchments. Number of square feet of impervious surfaces retrofitted to pervious surfaces.

Climate Change

Since the adoption of the first CCMP, climate change has increasingly become a focus of scientific research and public policy from the local to international levels. While there remains controversy in the public sphere concerning causation between human activities and rising global temperatures, there is strong scientific consensus that the global climate is changing, with average temperatures increasing. Many models suggest that this increase in temperature may affect weather patterns, precipitation, and sea levels, as well as numerous other environmental, economic, and social variables.

The scientific consensus and models at the global level do not directly translate to impacts at the local level. Individual cities and counties need high quality localized information and climate predictions to appropriately plan for future scenarios; however, this level of information requires detailed baseline data and advanced modeling analysis. A climate adaptation planning effort for San Luis Obispo County did present some predictions for the county as a whole, extrapolating global climate models to the local scale and using local expert knowledge and data. The final report from this effort suggests that by the end of this century the region could experience hotter, drier summers, more severe winter/spring storms, and sea level rise affecting coastal habitats and communities.[59]

Impacts from these predicted changes that will affect coastal areas of the county include: coastal inundation and sea level rise, ocean acidification, flooding, increased erosion from severe storms, increased risk of wildfire, and alterations in the distribution and viability of "edge" species most sensitive to these types of changes. Species and habitat distributions may be altered by changing climate conditions. Some species and habitats will suffer if appropriate areas for range expansion are not available due to other land uses. Timing of plant flowering and other reproductive or migratory patterns may be altered, throwing off symbiotic relationships. Reduced freshwater flow could impact estuarine species adapted to specific salinity conditions. Exotic and invasive species that may be better adapted to future conditions could outcompete native species. Ocean acidification could alter water chemistry in estuarine systems and result in biotic impacts.[60]

Economic impacts along the coast are possible due to changes in the climate. Increased infrastructure damage from more severe storms, flooding of municipal facilities and tourism-related locations, increased risk of damage to harbor and commercial fishing infrastructure, and unpredictable impacts to commercially important fish populations and aquaculture would all be detrimental to local economies.

The public policy response to climate change has taken two general forms: efforts to lessen carbon dioxide and other greenhouse gas emissions that contribute to warming, and efforts to encourage adaptation and mitigation strategies, which prepare communities for changes so that adverse impacts are reduced. In November 2011, the County of San Luis Obispo approved a climate action plan that outlines emissions reduction strategies to meet a 15% reduction in emissions from the 2006 baseline by 2020, as well as mitigation and adaptation strategies for climate change impacts predicted to occur even with such a reduction.[61] This plan includes strategies for the unincorporated areas of the Morro Bay watershed and County services in the city of Morro Bay. The climate action plan also served as the basis for an Environmental Impact Report (EIR) addendum to the EIR for the County's Conservation and Open Space Element of the General Plan. The city of Morro Bay has completed a baseline inventory for greenhouse gas emissions as part of an emissions reduction program of the San Luis Obispo Air Pollution Control District.[62] The city has not completed any additional climate adaptation planning at this time.

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[59] Koopman, M.E., Meis, K. and Corbett, J. 2010. Integrated Climate Change Adaptation Planning in San Luis Obispo County. The GEOS Institute and Local Government Commission, 47 pp. Accessed at: http://www.slocounty.ca.gov/Assets/PL/CAP-LUCE/climate_change.pdf

[60] Miller AW, Reynolds AC, Sobrino C, Riedel GF (2009) Shellfish Face Uncertain Future in High CO_2 World: Influence of Acidification on Oyster Larvae Calcification and Growth in Estuaries. PLoS ONE 4(5): e5661. doi:10.1371/journal.pone.0005661

[61] County of San Luis Obispo. 2011. Energywise Plan: Designing and Energy and Climate Solutions for the Future. San Luis Obispo, CA, 363 pp. Accessed at: http://www.slocounty.ca.gov/planning/CAP

[62] City of Morro Bay. 2005. Community-wide and Government Operations 2005 Baseline Greenhouse Gas Emission Inventory. Morro Bay, CA, 109 pp. Accessed at: http://www.slocleanair.org/programs/climatechange_general.php

The Morro Bay estuary and watershed is a complex system linked inextricably to its Mediterranean climate regime. Long-term changes to average temperatures and historic precipitation patterns will directly affect estuarine resources and ecological functions. Furthermore, rising sea levels, more severe winter storms, and altered precipitation patterns will have complex and costly impacts on the estuary, wetland and riparian areas, and bayside communities.

This management plan takes a two-tiered approach to addressing climate change in the Morro Bay watershed. In this section, three specific actions plans are described, focusing on the role the Estuary Program can play in advancing local understanding of, and adaptation to, climate change impacts. In addition to these action plans, there are many action plans in other sections of the plan that relate directly to addressing climate change impacts. These actions are marked with a ⦿ symbol to document this connection. This integrated approach is important because climate change impacts will be far-reaching and the strongest approach to addressing them is to integrate the issue into all relevant spheres of our science and conservation work. For actions that relate to restoration and conservation approaches, criteria must first be set for the goals of a particular project relative to climate change impacts. For example, there may be a range of predictions regarding sea level rise for a location. Before embarking on a restoration project in a location at risk of inundation, goals must be set regarding how the project will adapt to sea level rise.

CLIM-1 Encourage scientific endeavors and research into the effects of climate change on the Morro Bay estuary and its watershed.

Perhaps the most critical need in regard to climate change and the estuary is scientific study to better understand what local effects will be and what actions need to be taken. Most climate research has focused on global impacts and general predictions of precipitation and temperature patterns across large areas. As smaller cities and counties plan for climate changes and impacts, more specific data and modeling on the local scale is needed. Such focused research is critical to both planning and implementation of adaptation measures in the Morro Bay estuary, watershed and nearby communities.

As a conservation leader in the Morro Bay watershed, the Estuary Program can help promote the advancement of climate change understanding for local communities and resource managers, and support local efforts to predict impacts and plan for future changes. Some activities that the Estuary Program may complete to contribute to a stronger shared understanding of local climate change effects include

- Support of research activities to develop baseline datasets of current conditions that are likely to be impacted
- Support of research activities to develop vulnerability assessments, including ecological impacts of varying climate change scenarios
- Support of climate change modeling projects to predict sea level rise and other impacts in the bay, as a continued partnership with SLOSEA
- Technical and policy support to local municipalities to share scientific information and help managers interpret research and modeling results
- Participation in regional data collection and modeling efforts to leverage scientific capacity in other nearby coastal communities
- Facilitation of sharing of data and research results between partners and regional entities

Partners: Cal EMA, Cal Poly including SLOSEA, ICLEI, County of San Luis Obispo, DPR, DFG, NOAA, USEPA, TNC

Timeframe: Ongoing

Cost: $ - $$$$

Costs will vary widely based on the scope of research.

Implementation Tracking: The number and scope of research efforts. Workshops and other communication efforts to share information with municipalities and resource managers.

CLIM-2 Encourage the development and implementation of Climate Action Plans by the County, City of Morro Bay and Los Osos Community Services District.

Climate action plans (CAPs) outline strategies to reduce greenhouse gas emissions and prepare for impacts from climate change at the local or regional level. In California, climate action planning by cities and counties can be very effective as most land use and planning decisions are made at the local level. Governments in San Luis Obispo County are already on the forefront of planning for and adapting to climate change. The County and some cities in the region have begun addressing both emissions reduction strategies and adaptation policies through climate action plans. Many other cities, including Morro Bay, have completed greenhouse gas emissions inventories. Due to California's unique set of climate change vulnerabilities and its approach to land use planning as a local endeavor, the state has taken a leadership role by incentivizing climate action planning at the local level. Two key pieces of legislation – the Global Warming Solutions Act (AB 32) and the Sustainable Communities and Climate Protection Act (SB 375) – direct local governments to plan for emissions reductions and transportation planning to reduce climate change impacts.

San Luis Obispo County is also moving forward on incorporating climate change into more traditional planning documents. The County's Conservation and Open Space Element of the General Plan includes policies and implementation strategies that address climate change.[63] The County Hazard Mitigation Plan incorporates climate change in the risk analysis and sets a goal of curtailing the harmful effects.[64] Other planning efforts to increase energy efficiency, encourage alternative and communal transportation, and promote low impact development techniques also relate to climate change adaptation. The Estuary Program supports such efforts by our local agency partners to plan for future climate scenarios in an environmentally sustainable and community-oriented manner.

Climate adaption planning, and related planning efforts, presents an opportunity to promote sustainable use of local natural resources in a way that benefits economic, social, and environmental outcomes. The Estuary Program aims to encourage a more holistic approach that considers all of these outcomes when planning for climate change. The Estuary Program activities to support such an approach may include

- Participation in public planning processes to inform planning for coastal habitats and communities and increase integration of climate change planning into traditional planning documents
- Technical support to municipalities for creating CAPs or integrating climate change into other planning documents
- Collection and sharing of data to inform planning efforts at the local level
- Participation in the implementation of CAP and other planning strategies as they relate to the Estuary Program goals and priority issues
- Facilitation of collaboration among stakeholders and government agencies to increase climate change understanding, integrate planning efforts, and promote climate adaptation responses that provide positive environmental benefits
- Encouragement of the alignment of local planning efforts with regional and state efforts

Partners: County of SLO, City of Morro Bay, LOCSD

Timeframe: Timeframe for local plans and implementation contingent on priorities among the local governments.

Cost: $$

Implementation Tracking: Estuary Program participation in CAP and other planning processes. Type and specifics of data shared to inform planning efforts. Participation in implementation efforts, as appropriate.

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[63] County of San Luis Obispo, Department of Planning and Building. 2010. County of San Luis Obispo General Plan: Conservation and Open Space Element. San Luis Obispo, CA. 305pp. Accessed at: http://www.slocounty.ca.gov/Assets/PL/Elements/COSE.pdf

[64] County of San Luis Obispo, Office of Emergency Services. 2011. San Luis Obispo County Local Hazard Mitigation Plan. San Luis Obispo, CA. 189 pp. Accessed at: http://www.slocounty.ca.gov/Assets/OES/Plans/Hazard+Mitigation+Plan+2011.pdf

CLIM-3 Participate in or direct educational programs about the possible implications of climate change on the estuary and watershed, as well solutions and alternatives to address impacts; such programs should be consistent with state and local action plans or other adopted public policy. ★

Education and outreach are necessary components of any climate adaptation efforts. Many adaptation and emissions reductions strategies require the cooperation of individual citizens when they make daily decisions – what form of transportation to use, what type of car to buy, how close to live relative to their jobs, and how to landscape and improve their home in ways that will aid in climate adaption. Informing citizens about what actions can help mitigate future climate change impacts is the first step to making a difference in the local community.

The Estuary Program boasts a strong community education program and maintains partnerships with many community organizations, schools, and other educational efforts. Educating the public about local climate action plans and steps they can take to prepare is a natural role for the program. Any education efforts would be done in cooperation with other state and local agencies directly involved in climate action planning, and would be largely contingent on an improved, science-based understanding of localized climate change implications for the estuary and related resources. Some activities that may help implement this action plan include

- Development of education materials that explain climate action plans and ways citizens can help implement them
- Partnerships with other organizations and municipalities to develop climate change education materials and/or events
- Integration of climate change concepts and actions into other educational programming offered in the estuary and watershed

Partners: County of San Luis Obispo, City of Morro Bay, LOCSD, San Luis Coastal Unified School District and individuals schools, Central Coast State Parks Association, Cuesta College, and Cal Poly

Timeframe: Ongoing, but also contingent on the state of scientific knowledge (see CLIM-1) and information forthcoming in local Climate Action Plans (see CLIM-2).

Cost: $

Implementation Tracking: The number of education and outreach projects oriented toward the effects of climate change.

Environmentally Sound Estuarine Resource Use

Estuaries are well known for their rich environmental resources. But they are also valued for a wide variety of recreational, commercial, and industrial uses that thrive in coastal bays. Morro Bay serves many human uses: commercial fishing fleet, commercial aquaculture, power generation, tourism and related commercial uses, and many kinds of recreation. Some of these uses require significant alterations to the natural landscape while others are more passive pursuits. In addition, the scenic beauty of the bay attracts residential development and commerce to serve those residents. This broad array of uses highlights the need for maintaining balance between the uses humans depend on and the environment that makes those activities possible.

The communities within the Morro Bay watershed are small and close-knit. Most people are familiar with the recreational and commercial activities that occur on the bay. This familiarity helps mitigate some potential conflicts between different activities. Still, tourism (in the city of Morro Bay in particular) has increased significantly over the past decade and is likely to continue growing. With more people visiting and engaging in recreational activities, conflicts become more likely. Kayakers and paddle boarders may paddle in the channel designated for boats and fishing vessels, and may also disturb shorebirds that bird watchers come to see. Recreational boaters may disturb oyster farming operations. Denser coastal development and higher tourism visitation rates may increase litter and add marine debris to the estuary. These are just a few examples of possible conflicts – although some of them may never occur and others may be rare, they are important to plan for so everyone can enjoy the bay equitably.

Equitable and sustainable use of the bay also has great environmental advantages. A balance of human uses that is environmentally protective and responsible benefits the estuary and the people that depend upon it. Without such a balance, conflicts between uses often lead to environmental impacts – damaged and loss of habitats, disturbance of birds and other wildlife, and a greater volume of marine debris. Thus, an important issue facing the estuary's future is encouraging balanced and sustainable use of the land, water and other resources in ways that protect and enhance its environmental qualities.

RECREATIONAL USES

USE-1 Encourage the enjoyment of Morro Bay through environmentally responsible and sustainable recreational activities. *(Related 2001 actions: EDU-2 and EDU-8)* ★

Many residents of and visitors to the Morro Bay area enjoy recreating in the beautiful and peaceful natural surroundings of the estuary. Popular recreation activities span the spectrum from bird and wildlife watching, walking along the waterfront, and fishing to kayaking, paddle boarding, and SCUBA diving. These pastimes generally have low impact on the estuary and its natural resources. Furthermore, most people engaged in these types of outdoor activities feel positively toward the environment and do not intentionally cause harm. Even with good intentions, however, wildlife can be inadvertently disturbed and habitats can be accidentally damaged.

The Estuary Program educates recreational users of the bay about how to enjoy the bay in an environmentally responsible manner, while still taking pleasure in their activity of choice. These educational efforts also incorporate information about recreational practices that reduce conflicts with other uses, such as shellfish farming and commercial fishing. Past educational efforts include information exchanges with local kayak and canoe rental companies, recreational information at education events, educational materials encouraging bird watching in ways that minimize disturbances to water fowl, and collaborative education efforts to educate the public about nesting areas of the snowy plover.

In addition, the Estuary Program supports upgrades to existing bay and harbor facilities so that they can be better enjoyed and better managed to protect the environment – for example, through improved waste disposal from recreational and live-aboard boats.

Recreation, if conducted in a responsible manner, can increase appreciation of the sensitive resources of the area and inspire people to work toward their continued protection and enhancement. The Estuary Program will continue to work to educate recreational users with activities such as

- Continued collaboration with recreation-oriented businesses such as boat and kayak rentals, tour companies, marinas, and recreational fishing companies to encourage environmentally sound practices in their operations and to help educate their customers about how to enjoy the resources with minimum impacts
- Development of education materials to explain sustainable practices while also providing desired information, such as animal identification
- Education efforts to bring awareness about the variety of uses occurring on the bay and how to minimize undesirable interactions
- Field trips and other education events to increase general knowledge of local species and habitats and how to enjoy them with sustainable recreational practices
- Collaboration with resource managers to address observed conflicts

Partners: DPR, DFG, City of Morro Bay, County of SLO, DBW, California Coastal Commission, California State Coastal Conservancy, operators of commercial recreation outlets such as those offering kayak rentals and wildlife tours.

Timeframe: Ongoing

Cost: $

Implementation Tracking: Programs or projects that encourage responsible recreation; upgrades to relevant facilities to reduce impacts. Numbers of materials, events and trainings that distribute information on sustainable recreational practices.

SHELLFISH FARMING

USE-2 Support the continuation of ecologically sound shellfish farming in the bay. *(Related 2001 action: BACT-4)*

A viable shellfish aquaculture industry can be a bellwether of the health of an estuary. As filter feeders, shellfish remove organic matter, detritus, and nutrients from the water column.[65,66] This filtering process increases water clarity and can benefit water quality. Furthermore, shellfish is not suitable for human consumption when exposed to waters contaminated with bacteria and/or biotoxins. This water quality constraint provides economic motivation to improve water quality to maintain solvent shellfish farming operations. Detrimental environmental impacts from shellfish farming may be minimal at the scale at which farming occurs in Morro Bay. However, the specific methods used to grow and harvest shellfish can impact the surrounding environment. Of greatest concern is the possibility of impacts to nearby eelgrass beds. Current operations generally avoid impacts to eelgrass, but any future aquaculture activities should consider the methods used and species cultivated in the context of protecting estuarine resources like eelgrass.

Leases for oyster farming in nearshore waters are managed by DFG and are closely regulated by the California Department of Public Health (DPH). DPH requires water quality testing and monitors bacteria and biotoxin concentrations to ensure that shellfish are safe for consumption. The department also regulates harvesting and storage of shellfish until they are sold to consumers. In Morro Bay, the greatest regulatory issue for shellfish harvesting has been elevated bacterial concentrations in the growing waters. New or expanded aquaculture operations also require a coastal development permit from the California Coastal Commission.

The Estuary Program supports the continuation of ecologically sound shellfish aquaculture in the bay and has supported local operators and regulators with bacteria monitoring and data sharing efforts in the past. Actions that the Estuary Program may take to encourage good farming practices and reduce impacts include

- Continued measures that reduce bacteria pollution to the bay (see Best Management Practices section)
- Continued monitoring of bacteria levels in the creeks and the bay
- Support for research into the sources of bacteria entering the bay
- Encouragement of shellfish farming BMPs that reduce detrimental effects, such as encouraging dry storage of un-used farming materials
- Support for minimizing impacts to eelgrass beds (avoiding anchor or propeller scars and shading of beds by infrastructure) from operations located close to beds

Partners: DPH, DFG, State Lands Commission, NOAA NMFS, oyster farm operators.

Timeframe: Ongoing

Cost: $

Implementation Tracking: Sharing and analysis of bacteria monitoring data. Support for bacteria source research. Number of BMPs implemented by oyster farmers. Number of closure days not related to rainfall.

[65] Nelson, K.A., L.A. Leonard, M.H. Posey, T.D. Alphin, and M.A. Mallin. 2004. Using transplanted oyster (*Crassostrea virginica*) beds to improve water quality in small tidal creeks: a pilot study. Journal of Experimental Marine Biology and Ecology. 298: 347-368.
[66] Crawford, C., C. Macleod, and I. Mitchell. 2003. Effects of shellfish farming on the benthic environment. Aquaculture 224: 117-140.

COMMERCIAL FISHING

USE-3 Support the traditional use of Morro Bay as a commercial fishing port and working waterfront consistent with the protection of water quality and habitat values.

Morro Bay has a long and proud history as a fishing village with a vibrant working waterfront. Historically, the commercial fishing industry provided jobs, infrastructure, and economic benefit to the local community. However, the industry started to decline in the late 1980s due to reduced quotas and catch limits, stricter gear requirements, rising costs and competition, and an increase in areas closed to fishing offshore. This gradual decline led to dock infrastructure, such as unloading and processing facilities, falling into disrepair and commercial fishing vessels being abandoned in the Morro Bay harbor.

Degradation of dock infrastructure and the abandonment of vessels have both economic and environmental impacts. The greatest environmental danger is the release of toxic materials and debris from abandoned vessels and the risk of increased debris from facilities in disrepair. Lack of facilities also forces fishermen still operating from the harbor to use less environmentally sound practices in unloading fish and maintaining their vessels. Economic impacts include loss of jobs and loss of municipal income. Furthermore, degrading infrastructure and abandoned vessels pose significant legal and financial risk to the city of Morro Bay, as ownership often reverts to the city of Morro Bay after abandonment. This risk is challenging to manage, and the Estuary Program has been an engaged partner in helping the city reduce risks by removing abandoned vessels and mitigating degrading infrastructure.

Recently, the Morro Bay fishing industry has experienced some positive growth and implementation of sustainable practices. A partnership between local fishermen, the Nature Conservancy, and the City of Morro Bay aims at transitioning the local groundfish fishery to more environmentally sound gear types and more sustainable business practices. By focusing on catching smaller amounts of higher quality fish, local fishermen have been able to increase revenues and expand business opportunities. Other recent local improvements include the completion of an ice facility in the harbor and the successful operation of three offloading sites.[67]

The revival in local commercial fishing has some potential benefits for the estuary, as long as environmentally sound practices are used. Commercial fishing encourages stewardship of local resources because fishermen depend on a safe and clean harbor from which to operate. The long-term nature of many fishing operations (passed down from generations) means that people engaged in the industry are committed to Morro Bay and likely to feel connected to the local environment. In a broader sense, commercial fisheries depend on estuaries as nursery habitats for commercial viable species. Having commercial fishing anchored in Morro Bay increases awareness and appreciation for this important relationship between estuaries and fisheries.

The Estuary Program supports efforts to maintain the Morro Bay heritage of commercial fishing using practices that protect water quality and habitats. Activities to support such efforts might include

- Supporting efforts to increase facilities for proper boat management (see BMP-8 and BMP-9)
- Education and research efforts to increase awareness and understanding of the relationship between estuary habitats and commercial fisheries
- General and technical support for activities that encourage environmentally sound fishing practices
- Continued assistance to the City of Morro Bay to remove or repurpose abandoned vessels

Partners: Commercial fishermen, Morro Bay Commercial Fishermen's Organization, Central Coast Women for Fisheries, City of Morro Bay, DFG, NOAA NMFS, TNC, Cal Poly including SLOSEA, California Coastal Commission, California State Coastal Conservancy, private foundations and other funders

Timeframe: Ongoing

Cost: $ - $$$

[67] Morro Bay and Port San Luis Commercial Fisheries Business Plan. 2008. Prepared by Lisa Wise Consulting for the City of Morro Bay, Morro Bay CA. 200 pp. Accessed at: http://www.morro-bay.ca.us/documents/Harbor/MB_PSL%20Business%20Plan%202008.pdf

Implementation Tracking: Implementation of boat maintenance facilities and other good practices. Number of abandoned vessels removed or repurposed. Engagement in support activities for sustainable fisheries development. Engagement and support of partners' efforts in research of connections between estuaries and commercial fisheries.

MORRO BAY POWER PLANT

USE-4 Discourage the continued use of once-through cooling at the Morro Bay Power Plant; if this practice is continued, encourage minimization of impacts to estuary species and ecosystem services by working with the Central Coast Regional Water Quality Control Board, California Coastal Commission, California Energy Commission and other permitting agencies. *(Related action from 2004 CCMP amendment: HAB-11)*

The Morro Bay power plant is an aging facility constructed and first operated in the 1950s. Over the years, different plant owners have considered modernizing and expanding the plant in its current location. Efforts were especially pronounced in the 2000s when California was facing acute electricity shortages. Permitting agencies, especially the Water Board, California Energy Commission and California Coastal Commission, undertook extensive studies of the impacts of the plant, focusing on the cooling system by which cold water from the estuary is pumped through the facility's cooling system one time and then discharged into the ocean at higher than natural temperatures.

The primary concern with this "once-through" cooling is that large numbers of fish larvae and fry (young fish at the post-larval stage) and invertebrate larvae are impinged or killed. Termed entrainment, larvae and small fish are drawn into the facility during the cooling intake process and are killed by pressure and high temperatures.[68] Arrow goby are the most common fish entrained at the Morro Bay Power Plant.[69] Other species, including brown rock crab and other rock crabs, are also impacted. Impingement is another impact to fish larvae whereby fish are trapped against screens that filter the water coming into the plant.

In 2004, the USEPA issued a regulation, as required by law, designed to reduce the number of organisms impinged and entrained in water-cooled power plants by up to 95 percent. The ruling provided a number of alternative methods of compliance, including existing technologies, selecting additional fish protection technologies (such as screens with fish return systems), and using restoration measures. In 2011, EPA suspended that regulation in preparation for issuing a new rule that sets specific limits on impingement and requires site-specific studies for entrainment. Any additional generating capacity added to an existing plant would have to use the more advanced technology of closed-cycle cooling.[70]

Under the current the Section 316(b) of the Clean Water Act, the State Water Board regulates cooling water intake structures, including the Morro Bay Power Plant. The State Water Board's Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling establishes technology-based standards to reduce the harmful effects associated with cooling water intake structures on marine and estuarine life.[71] Under the current regulations, permittees must either reduce intake flow and velocity to meet the regulation requirements or reduce impacts to aquatic life in a comparable fashion using other means. The current (2011) implementation plan for the Morro Bay Power Plant, owned by Dynegy, calls for reducing impacts to aquatic life through impingement and entrainment control measures.[72] The plant is scheduled to comply with current regulations by December 1, 2015. If it has not been able to implement necessary control measures, the cooling intake units will be taken offline until they can become compliant. If Dynegy determines that compliance is not possible, the operating units may be repowered (likely with fossil fuel technologies).

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[68] Bailey, D. Electric Power Research Institute. 2007. Assessment of Cooling Water Intake Structure Impacts to California Coastal Fish and Fisheries. Palo Alto, CA. 136 pp. Accessed at: http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/docs/epri_assessment_impacts.pdf

[69] Morro Bay Power Plant Modernization Project – 316(b) Assessment. Prepared by Tenera for Duke Energy Morro Bay, LLC. 182 pp. Found at: http://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/powerplants/morro_bay/docs/mb_ip2011attb1.pdf

[70] U.S. Environmental Protection Agency. 2011. Fact Sheet: Proposed Regulations to Establish Requirements for Cooling Water Intake Structure at Existing Facilities. Washington, D.C. 2 pp. Accessed at: http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/factsheet_proposed.pdf

[71] State Water Resources Control Board. 2010. Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling. 18 pp. Accessed at: http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/docs/policy100110.pdf

[72] Dynegy Morro Bay, LLC. 2011. Implementation Plan for the Morro Bay Power Plant. Morro Bay, CA. 31 pp. Accessed at: http://www.swrcb.ca.gov/water_issues/programs/ocean/cwa316/powerplants/morro_bay/docs/mb_ip2011.pdf

In Morro Bay, the current plant owners (Dynegy) operate the facility as a peaking unit and there is no active permit being processed for expansion or modernization. The plant is currently in the process of renewing its NPDES (National Pollution Discharge Elimination System) permit with the Water Board.

In 2004, the CCMP was amended by the Executive Committee to recognize the problems associated with once-through cooling. The use of once-through cooling is very detrimental to fish and invertebrate populations in nearshore estuaries and has become a more significant permitting issue in light of the USEPA's proposed new ruling and recent studies. Considering the serious impacts, and the minimal current use of the Morro Bay Power Plant, once-through cooling should be discontinued. However, if regulatory bodies continue to let the power plant operate with the current cooling system, efforts should be taken to minimize impacts from entrainment and impingement. Actions the Estuary Program may take to support such efforts include

- Support efforts by partners and others to evaluate possible approaches to minimizing impacts of the current once-through cooling system
- If plant expansion were to be considered, support for studies of impacts to fish and invertebrate populations from any expansion plans

Partners: California Energy Commission, Water Board, California Coastal Commission, City of Morro Bay, CAPE

Timeframe: Unknown

Cost: $-$$

Implementation Tracking: Status of efforts to study plant impacts, based on regulatory standards and plans for expansion.

URBAN DEVELOPMENT

USE-5 Encourage development in the watershed that occurs in existing and strategically planned communities, preserves the local sense of place, reduces urban sprawl, and minimizes impacts to water quality and important habitats. ★ ◉

With its mild climate, productive land, unique geologic landscape, and proximity to the coast, the Morro Bay watershed has drawn human inhabitants for thousands of years. The modern human landscape includes the small coastal towns of Los Osos and Morro Bay, surrounded by mostly rural terrain with sparse development. In the upper portion of the Chorro Creek sub-watershed, development includes a state university (Cal Poly), community college (Cuesta College), a state prison (California Men's Colony), Camp San Luis National Guard base and a regional County park with a golf course and playing fields.

Coastal development is an integrated presence in the watershed, one that will be here for many generations to come. This development has economic benefits to the area, such as job creation and tourism, but can also cause environmental harm. Development changes the natural landscape, reduces native habitats, competes for scarce water resources, and introduces pollutants to the environment. But the environment and human communities are inextricably linked – the natural setting of the Morro Bay watershed is one of the unique aspects of living in this region and draws many people and visitors. A strategic approach to future development can limit harm to water quality and important habitats, preserve the local sense of place, and reduce urban sprawl. There are also existing constraints that shape development patterns. Resource limits that have slowed the pace of urban growth include water availability in Morro Bay and sewage treatment capacity in Los Osos. Future impacts to those resources (especially water availability) in the face of climate change will alter development potential and patterns.

The Estuary Program supports municipal and county efforts to strategically plan development, minimize environmental impact, and maximize livability for citizens. A central tenet of such a strategic approach is to encourage development in existing communities (rather than growing into undeveloped areas). Another tool is to use development practices that minimize impacts on the environment. Such practices as Low Impact Development (LID) preserve a site's natural hydrology and landscape and minimize stormwater runoff. A more subtle approach is to infuse within land use planning a strong desire to preserve the natural sense of place – which for Morro Bay and Los Osos includes natural habitats – and encourage development that increases walkability and other livable characteristics of a community.

The Estuary Program has supported these approaches to development through a number of actions. The Bay Foundation, the non-profit umbrella organization for the Estuary Program, provides administrative and staff support to the Water Board's LID Initiative that assists local government agencies with formulating LID guidelines and in designing and permitting projects that incorporate LID principles. The Estuary Program has supported trainings for local planners to learn about recent advancements in strategic growth principles that reduce sprawl and increase livability. The Estuary Program has also worked to reduce future potential for sprawl development by growing greenbelts along the urban limits of Morro Bay and Los Osos (see also LA-3). Future activities to continue this support of strategically planned development may include

- Leadership and support for land acquisitions and conservation easements that limit sprawl potential (see LA-3)
- Training and other technical support to assist local planners in implementing land use planning strategies that minimize environmental impact while preserving the sense of place and livability of local communities
- Administrative and technical support for the LID Initiative, as well as encouraging continued partnerships in the watershed between LID Initiative and municipalities
- Implementation and support for LID and stormwater demonstration projects (see BMP-5, BMP-7)

Partners: Water Board including the LID Initiative, City of Morro Bay, County of San Luis Obispo, Local Agency Formation Committee, California Coastal Commission, California State Coastal Conservancy, WCB, DFG, DPR, LOCSD, Los Osos Community Advisory Council (LOCAC), SWAP, Morro Coast Audubon Society, among other public agencies, as well as private land owners.

Timeframe: Ongoing

Cost: $$

Land and easement acquisitions are covered in the Land Acquisition section of the action plans.

Implementation Tracking: Status of the greenbelts. Type, amount and location of development approved in the watershed. Participation and support for trainings and technical support for strategic land use planning.

Education and Outreach

Many of the actions in this CCMP involve changing the behavior of individuals that live and work in the Morro Bay watershed. Behavior changes can require some technical skill, such as using agricultural best management practices, or be as straight forward as picking up after one's pet on a walk. As a non-regulatory organization, the Estuary Program's key tool for encouraging behavior change is through outreach and education to appropriate audiences about how to live, work, and recreate in and around the estuary in environmentally friendly ways. Part of achieving positive behavior changes includes increasing awareness about basic estuary science. People are more likely to make positive changes and minimize impacts to the surrounding environment when they understand and feel connected to that environment and the organisms that inhabit it. In this way, education and outreach serve as the backbone for all of the work of the Estuary Program.

"Education" refers to efforts to teach estuary science and other relatively complex concepts to specific audiences through repeated interactions and learning tools. "Outreach" refers to more general efforts to increase general awareness and literacy of estuary concepts and behavior changes to broader audiences during short, more opportunistic interactions.

In fact, many of the action plans in previous sections of the CCMP include education and outreach components, as noted by the ★ icon. This section includes additional action plans focused on broader education and outreach efforts that increase awareness of the general ecology of the estuary and the services it provides to the local coastal communities (such as recreational opportunities and flooding protection). The broad nature of these action plans may also help expand the audience interested in the Estuary Program and the estuary. Additionally, the education action plans in this section aim to share information from projects and monitoring completed by the Estuary Program and its partners.

Since adoption of the first CCMP, the Estuary Program has undertaken numerous education programs to: increase public appreciation the estuary's importance; share results from the VMP and other research efforts; encourage community projects that benefit the watershed and estuary environment; and support partners that involve the community in estuary-related work. Examples of resulting educational materials and projects, many undertaken with partner organizations and agencies, include

- An informational map that highlights estuary resources and the Estuary Program partners
- A series of public-friendly booklets covering the geology and physical characteristics of the estuary, bird life, and water quality
- A public service announcement for local television about the estuary and the Estuary Program
- A nature center highlighting estuarine resources and ways to enjoy the bay while protecting resources
- Storm drain stenciling and plaques
- Clean boating informational packets and signs
- Informational and interpretive signs along the waterfront
- Summer camp programs to provide coastal environmental experiences for underserved youth
- Storm water pollution prevention media campaign
- Bayside Living Guide, which details how to reduce impacts to the bay from everyday life
- Teacher workshops and K-12 educational materials
- Special events, field trips and booths at community functions
- Multi-day "State of the Bay" triennial event
- Estuary Tidings and other progress reports explaining the status of the bay by specific metrics
- Quarterly print and electronic newsletters sharing updates from the Estuary Program and partners
- Informative website and other multimedia tools to share information
- Public meetings on important estuary issues
- Regional conferences on estuarine and watershed resources
- Awarding education mini-grants to various partners
- Development of a community volunteer program, in addition to the VMP

The Estuary Program will continue to inspire human connections to the estuary, encourage behavior that benefits the environment, foster wider community participation in protecting and enhancing estuarine resources, and communicate scientific research about changing conditions of the bay and watershed.

PUBLIC EDUCATION AND OUTREACH

EO-1 Conduct general public education and outreach focused on the value of a healthy environment and the role of individuals in protecting the natural resources of the Morro Bay watershed, and to communicate the results of the Estuary Program conservation and monitoring efforts. *(Related 2001 action: EDU-1, EDU-7, and EDU-10)* ★

Increasing awareness about the plants, wildlife, and ecology of the estuary supports the health of the estuary and every project of the Estuary Program. As illustrated by the educational projects accomplished since the original CCMP was adopted, various media and methods can be employed to increase awareness, explain environmentally friendly practices, and share conservation and monitoring results. These methods include exhibits and signage, publications and information packets, electronic media materials and outlets, participation in community events, education field trips, nature exhibits, and hosting conferences and public workshops. The most effective method employed in a particular situation depends on the target audience, nature of the information to be communicated, and cost constraints. Education and outreach efforts are both strategic, planned to address important issues, and opportunistic, taking advantage of events, partnerships or funding that will leverage effectiveness on relevant messages to important audiences.

The Estuary Program utilizes an Education and Outreach Working Group to help set priorities and to develop annual work programs. This group of local educators and outreach professionals guides the efforts of the programs and acts as liaisons to the community at large.

One of the Estuary Program's most popular and effective education efforts is the mini-grant program. Mini-grants are awarded to local agencies and organizations who undertake education projects that implement CCMP action plans. Since the program was instituted in 2001, the Estuary Program has awarded 50 grants totaling approximately $180,000 to dozens of partners. Projects include signage, educational publications, displays, and special events, among many others. Frequently, mini-grants partially fund much larger projects, thus significantly leveraging scarce education and outreach funding available to local organizations.

Future public education and outreach efforts by the Estuary Program might include

- Continuation of regular communication avenues, such as newsletters and the website
- Maintenance and enhancement of the Estuary Nature Center
- Expansion of a community volunteer program providing volunteer opportunities beyond the VMP
- Partnership efforts to increase awareness of the estuary and behavior changes, such as educational signage, events, and focused media campaigns
- Facilitation of specific behavior changes through program such as Mutt Mitts

Partners: Virtually every participating agency and organization in the Estuary Program is involved in general outreach and educational programs.

Timeframe: Ongoing

Cost: $ - $$$

Implementation Tracking: The number and nature of educational and outreach projects and materials, including the number of persons in the target audience reached by them. Mini-grants awarded and leverage ratios.

STATE OF THE BAY

EO-2 Host triennial "State of the Estuary" information exchange effort and prepare a public friendly report to review progress on CCMP implementation, to communicate scientific knowledge about the estuary, to recognize and address challenges, and to educate and engage the public about estuary issues. *(Related 2001 action: EDU-5)* ★

Many community members trace the original impetus for creating the Estuary Program to a State of the Bay conference undertaken by concerned volunteers in the 1980s. The power of this type of event to communicate information and to galvanize action was clearly demonstrated. Since the adoption of the original CCMP, the Estuary Program has hosted three State of the Bay events, the most recent in 2010. This information exchange and outreach effort provides a forum for communicating the latest science about Morro Bay to a spectrum of audiences. Some portions of the event focus on exchanging technical information between practitioners and scientists, while other components engage the general public and environmentally literate citizens. The State of the Bay also updates the community on the status of the CCMP's implementation and on several environmental indicators of the health of the estuary.

Executing this complex, multi-day effort requires planning at least a year before the event. The program not only requires basic logistical work (venues, agendas, speakers/papers, publicity) but also on the organization and assembly of the underlying science. This requires a lengthy process of analyzing multiple years of monitoring data and conservation results in a comprehensive and easy-to-understand form. Even before data is analyzed, a myriad of potential topics must be assessed to find those most relevant and timely.

A public friendly report is released in advance of the State of the Bay and describes the basic health of the estuary. The data and technical analyses that underlie this publication are carefully portrayed in ways easily understood by the general public. The accumulation of the science, its translation to be most meaningful to the community, and then the writing, illustrations, layout, printing and distribution constitute a substantial effort for the Estuary Program.

Future efforts to continue State of the Bay and the related publication may include

- Evaluation of the indicators used in the public friendly report to describe the health of the estuary, and determining whether these questions are adequate or need updating
- Data analysis and supporting preparation for the public friendly report every three years
- Organizational efforts to continue the triennial State of the Bay, incorporating innovative communication techniques and new event formats
- Targeted outreach efforts to expand the audience for the State of the Bay

Partners: Various volunteer speakers and presenters, DFG, DPR, Cal Poly including SLOSEA, Water Board, California Coastal Commission, City of Morro Bay, County of San Luis Obispo, CSLRCD, UCCE, among others, have participated in presentations in previous years. In addition, private consultants and local experts have also participated.

Timeframe: The next State of the Bay will be held in 2014.

Cost: $

Implementation Tracking: The events and accompanying reports; the number of attendees.

NATURE CENTER AND RELATED DISPLAYS

EO-3 Continue to maintain a public environmental information display at the Estuary Program offices that educates people about estuarine resources and encourages the protection of those resources; continue to support the efforts of the Central Coast State Parks Association, California Department of Public Resources, and other organizations that provide similar displays and exhibits. *(Related 2001 action: EDU-6)* ★

One of the more visible projects of the Estuary Program has been the estuary nature center, located adjacent to the program offices in Morro Bay. The nature center is an important avenue to reaching general public members and visitors that may otherwise be unaware of the Estuary Program and the unique environment of the estuary. The center includes artwork, taxidermy, live fish, an eelgrass display, and other exhibits that educate visitors about the estuary's resources and ways to live in and visit the area while minimizing impacts to those resources. Certain elements of the center are permanent, while others rotate to address issues of current emphasis. Funding and support for the exhibits has come from numerous sources, including the USEPA, Coastal Commission, and local businesses and foundations.

Another important venue for informational and interactive exhibits is the Museum of Natural History located in Morro Bay State Park. The Estuary Program has collaborated with the Central Coast State Parks Association (CCSPA), the non-profit that supports the museum with DPR, with mini-grant funding, special events, field trips, youth camps, and other educational programs. In addition to the Estuary Program nature center and the museum, a few other groups maintain educational displays relevant to estuarine resources, including SWAP, the County of San Luis Obispo, and the Pacific Wildlife Rehabilitation Center. The Estuary Program supports these partners' efforts.

Future activities to continue the nature center and related displays might include

- Increased education programming offered in association with the Estuary Nature Center and other displays
- Enhancement of permanent exhibits to update scientific knowledge and incorporate new technologies
- Creation of innovative, new rotating exhibits to draw repeated visitors

Partners: USEPA, CCSPA, DPR, SWAP and numerous other funders

Timeframe: Ongoing

Cost: $

Implementation Tracking: The ongoing operation of the nature center; number of visitors.

FORMAL EDUCATION PROGRAMS

EO-4 Continue to provide educational opportunities focusing on estuary and watershed science and conservation for PK-12 schools and college programs, as outlined in the Education Strategic Plan. *(Related 2001 action: EDU-9)* ★

The Morro Bay estuary provides an excellent learning ground for all ages, but especially for school-age and college students. Lessons learned at school about the importance of the estuary and watershed, environmental science, and the ways people can affect the environment are frequently carried into the home to parents and siblings. Exciting students about estuary science can also be the starting point to scientific and conservation-oriented careers.

The Estuary Program's formal education efforts have focused on presentations and special events coordinated with local schools, as well as hosting field trips for local students and out-of-area underserved populations. In addition to direct contact with students, the Estuary Program has also conducted teacher training programs to strengthen environmental science, and estuary and watershed relevancy, in the curriculum. The Estuary Program will work toward a strategic approach on how the program can best assist local schools in enhancing their natural science curricula. In addition to working with schools, the Estuary Program has partnered with other organizations, such as the CCSPA, to provide formal education programming, such as field trips, teacher training, and day camps.

At the college level, the Estuary Program staff regularly lecture and lead lab sessions in oceanography, ecology, planning, environmental engineering, and environmental science courses. These lectures provide students an opportunity to hear about science from people working on the ground and using scientific knowledge in their everyday endeavors. This kind of interaction can make scientific concepts, and scientific careers, more meaningful and accessible to students. The Estuary Program also supports student projects, including master theses and senior projects, to encourage young researchers to expand their knowledge of the estuary and its unique ecology.

Future activities to continue formal education work may include

- Teacher training opportunities to increase educators' understanding of estuary science concepts and their ability to apply those concepts in the classroom
- Collaborative work with local schools and teachers to increase estuary science in curricula
- Education field trips and other opportunities for students to learn outside and engage in the environment
- College-level lectures and lab sessions
- Mentorship of students desiring to complete scientific research about the estuary

Partners: San Luis Coastal Unified School District, California Coastal Commission and the Whale's Tail program, CCSPA and DPR, Cal Poly, Cuesta College

Timeframe: Ongoing

Cost: $

Implementation Tracking: The number and nature of school-related programs; the number of students participating; the number of teachers trained.

Chapter 4 Acronyms & Abbreviations

Please refer to this list as you read through the CCMP:

ACOE	Army Corps of Engineers
ANEP	Association of National Estuary Programs
BF	Bay Foundation of Morro Bay
BLM	Bureau of Land Management
BMP	Best Management Practice
Cal EMA	California Emergency Management Authority
CAL-EPA	California Environmental Protection Agency
Cal Poly	California Polytechnic University
Camp SLO	Camp San Luis Obispo, California National Guard
CAP	Climate Action Plan
CAPE	Coastal Alliance on Plant Expansion
CCAMP	Central Coast Ambient Monitoring Program
CCC	California Conservation Corps
CCER	Chorro Creek Ecological Reserve
CCMP	Comprehensive Conservation and Management Plan
CCSPA	Central Coast State Parks Association (formerly Central Coast Natural History Association)
CDBW	California Department of Boating and Waterways
CDF	California Department of Forestry and Fire Prevention
CDPH	California Department of Public Health
cfs	Cubic feet per second
CMC	California Men's Colony
CREEC	California Regional Environmental Education Community
CSD	Community Services District
CSLRCD	Coastal San Luis Resource Conservation District
CWA	Clean Water Act
DBW	California Department of Boating and Waterways
DFG	California Department of Fish and Game
DO	Dissolved oxygen
DPR	California Department of Parks and Recreation (includes California State Parks)
ESA	Endangered Species Act
GIS	Geographic Information System
ICLEI	ICLEI – Local Governments for Sustainability
IWMA	Integrated Waste Management Authority
JPA	Joint Powers Authority
LIDI	Low Impact Development Initiative
LOCAC	Los Osos Community Advisory Council
LOCSD	Los Osos Community Services District
NEP	National Estuary Program
NEPA	National Environmental Protection Act
NERR	National Estuarine Research Reserve
NERRA	National Estuarine Research Reserve Association
NNE	Numeric nutrient endpoint
NOAA	National Ocean and Atmospheric Administration
NOAA Fisheries	National Ocean and Atmospheric Administration National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Science
OSPR	Office of Oil Spillage Prevention and Response (within Department of Fish and Game)
QAPP	Quality Assurance Project Plan

SCCWRP	Southern California Coastal Water Research Project
SLO	San Luis Obispo
SLOSEA	San Luis Obispo Science and Ecosystem Alliance
State Water Board	State Water Resources Control Board
SWAP	Small Wilderness Area Preservation
SWPPP	Storm Water Pollution Prevention Plans
TMDL	Total Maximum Daily Loads
TNC	The Nature Conservancy
TPL	Trust for Public Land
UCCE	University of California Cooperative Extension
USDA	United States Department of Agriculture
USDOF	United States Department of Forestry
USEPA	United State Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV	Ultraviolet
VMP	Volunteer Monitoring Program
Water Board	Central Coast Regional Water Quality Control Board
WCB	Wildlife Conservation Board
WWTP	Wastewater treatment plant

Appendices

The following appendices will be included with the final CCMP document. All of the 2001 versions of these appendices can be viewed at the Estuary Program's offices at: 601 Embarcadero, Suite 11, Morro Bay CA 93442. Some of these appendices will be partially updated for the final CCMP document. All will be available electronically with the final CCMP document.

A. Participants
B. Description of Management Conference
C. Glossary
D. Characterization Report
E. Monitoring plan (QAPP)
F. Finance plan
G. Public participation strategy
H. Federal Consistency report
I. Management Conference agreement
J. Base Programs inventory and analysis
K. Clean Water Action Section 320

Some additional documents will also be prepared to accompany final CCMP document: a summary of education and outreach components in the CCMP, a comparison of the 2001 and current (2012) CCMP, and a document summarizing the comments received on the draft and how they are addressed in the final CCMP.

San Antonio and Nacimiento Rivers Watershed Management Plan

October 2008

Prepared by
the Nacitone Watersheds Steering Committee and
Central Coast Salmon Enhancement, Inc.

Prepared for
the Monterey County Water Resources Agency and
the State Water Resources Control Board

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Executive Summary

There are two aspects to the development of any watershed plan. Dedicated people spent countless hours discussing concerns, issues and potential solutions to problems. This dedication leads to the production of documents that hope to articulate the outcome of the dialog in a way that is useful for the community. The executive summary identifies the Nacitone Watersheds Management process and products, and attempts to capture the major core findings arising out of both efforts.

The Vision

The Nacimiento/San Antonio River Watersheds Management Plan should protect water quality and watershed uses for all stakeholders.

The Purpose

The purpose of the Nacitone Watersheds Management Plan is to identify the existing conditions of and stresses in these watersheds as they relate to water quality, and recommend methods for reducing or eliminating those stressors such as alternative land use practices.

The Process

The Nacitone Watersheds Management planning process is a stakeholder driven process that represents the interests of residents, agencies and businesses that work and live in the watersheds. The stakeholder process used to produce these products presents an investment of 8800 volunteer hours of time in meetings, field trips, community outreach and planning. The magnitude of the effort includes far more than this if one includes the hundreds of contacts made through flyers, press releases and web-site visits. Each of the products was placed on the web-site for public review. Public comment periods were held for the Goals and Strategies document and the Watershed Management Plan. There were Steering and Technical Advisory Committees as well as a staff team guiding the process and development of the products. The members of each are listed in the acknowledgement section of the plan and referenced in Part 1 "How the Plan was Prepared."

The Products

The Nacitone Watersheds Plan was initiated by the Monterey County Water Resources Agency (MCWRA) and funded by a grant from the Regional Water Quality Control Board. As part of the grant, several products were produced to assist the watershed stakeholders in gathering and analyzing existing information about the watersheds to discern critical issues facing the watersheds and potential remedies. These products include:

Watershed Resources Inventory (WRI)—Existing watershed information was identified including reports, studies, maps, Geographic Information System (GIS) files, and technical data covering land use, water supply, water quality, ecology, hydrology, habitat and vegetation, agricultural and grazing practices, and planning efforts. The inventory is comprised of a spreadsheet file containing over 300 entries as well as an annotated bibliography of a select number of the entries.

Analysis of the WRI (Analysis)— Existing information was compiled in order to establish a baseline describing existing watershed conditions including land use, major water features, water quality, water supply, designated beneficial uses, point and nonpoint sources of water pollution, population, infrastructure, vegetation and habitat, and agricultural and grazing practices. Trends were identified for those items that had sufficient historical data. The Analysis did not include a technical review of compiled information.

Grazing Land Management Plan—the Upper Salinas/Las Tablas Resource Conservation District conducted an assessment of the 24,000 acres of grazing land owned and managed by the MCWRA at the Nacimiento and San Antonio Reservoirs to determine impacts on water quality, maintenance of ecological communities, and management of sustainable and restorative grazing.

Watershed Goals and Strategies—The WRI and Analysis were utilized by the stakeholder group to articulate goals and planning strategies for future watershed activities that focus on water quality improvements. These include non-regulatory approaches to watershed protection, integration of watershed planning with existing government planning activities, land use planning strategies for watershed protection and potential partnership scenarios which could serve to protect the health of the watershed. In addition, the stakeholders identified research and monitoring opportunities to fill data gaps to address issues of concern, identified many roles and associated responsibilities of stakeholders in implementation of the proposed actions and strategies as well as draft time frames for implementation.

Watersheds Management Plan—The Plan is an integration of the above products and includes the geographic boundaries of the watershed, a description of the natural resource conditions within the watershed, a series of goals, objectives and implementation measures for achieving and sustaining water quality improvements, and description of how to monitor, update and maintain the Plan as a living document. The plan is divided into four sections.

- Part 1 includes purpose and need for the plan and plan preparation.
- Part 2 is the Existing Conditions section which identifies physical and current conditions of the watersheds.
- Part 3 is the Watershed Strategy which identifies roles, responsibilities and potential implementation measures for protecting watershed health.
- Part 4 includes the jurisdictional and regulatory framework.

Appendices to the Plan include complete auxiliary supporting documents (The Grazing Lands Management Plan and the Nacitone Watershed Resources Inventory Final Technical Memorandum—Water Resources, Water Quality and Sediment Supply prepared by Swanson Hydrology and Geomorphology), WRI Spreadsheet and Annotated Bibliography, public and Technical Advisory Committee (TAC) comments, Low Impact Development (LID) primer, Resources for Residents and Landowners, Community Services Area (CSA) 7 Interceptor Bypass Study Executive Summary, Watershed Strategy Priorities Chart and maps.

The Core Findings

There is an abundance of information about the watersheds and while there is great concern about present and future water quality, the Klau/Buena Vista Mines Mercury situation appears to be the only documented water quality issue in either watershed. Stakeholders have become aware that while there may be additional water quality problems, there is no coordinated monitoring approach to determine level of concern.

The complexity of landownership and cross-jurisdictional authority of both San Luis Obispo and Monterey Counties present unique challenges for resolving present and future water quality concerns. The addition of state and federal regulations for source water supply and water quality can add further complexity to local efforts in that finding solutions to water quality issues can lead residents and landowners to conflicting regulations.

The interests of stakeholders living and working in the watersheds and the interests of the MCWRA and other agencies have not always been well aligned. This plan attempts to, in part, rectify this situation as the MCWRA and the stakeholders begin to share responsibility in finding ways to effectively manage watershed resources.

The Watershed Strategy (Part 3) is structured toward partnership approaches to water quality protection.

Legacy landowners (those who have been stewards of the land for generations and may date back to original land grants) play a central role in establishing desired outcomes in terms of defining future trends within a watershed.

The Steering Committee considered the following list to be the top priorities for action in the Nacitone Watersheds over the short and long term. (See table on following page.)

Prioritization of Plan implementations (recommended actions)

Top priorities that emerged from the stakeholder process :	
Short term (1-2 years)	**Long term (5-10 years)**
Continue the Nacitone Watersheds Steering Committee by seeking funding and contracting with a watershed coordinator/grant writer.	
Support the development and maintenance of Round Tables with an Inter-county Task Force on land use and water resources planning as the top priority Round Table (Issue 7)	
Monterey County, San Luis Obispo County and resident associations should work together to develop and implement programs to control invasive species. (Issue 11, Implementations 1C)	
Water quality monitoring, interpretation, and coordination across multiple entities. Continue existing water quality monitoring. In addition, establish a comprehensive water quality monitoring program with uniform collection, analysis and reporting protocols across pertinent jurisdictions for technical and public sector use. As part of this information gathering, encourage EPA to conduct a lake bottom sediment study of Nacimiento reservoir to better understand mercury contamination.	Support for SLO County to eliminate the risk to water quality of the Oak Shores Interceptor line at Nacimiento reservoir.
Support the work of existing Local Fire Safe Councils (Issue 5, Implementation 1B)	
Conduct road system survey to prioritize needs for erosion control. Include a focused survey on the Tank Road in coordination with military, etc. (Issue 9, Implementations 1B and 2B)	Implement proposed upgrades to the Tank Road and others within these watersheds in coordination with others. (Issue 9, Implementation 2B)
Collaborate on the design and implementation of educational stewardship campaigns targeting watershed residents and visitors with customized messages such as “Be A Watershed Citizen.”	

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PART 1
Introduction

A. Purpose and Need for the Plan

The purpose of the Nacitone Watersheds Management Plan is to identify the existing conditions of and stresses in these watersheds as they relate to water quality, and recommend methods for reducing or eliminating those stressors such as alternative land use practices.

The Monterey County Water Resources Agency (MCWRA) has an interest in creating a plan for the following reasons:

- The reservoirs and their respective watersheds are the source for water recharging the Salinas Valley groundwater basin.
- There is a direct correlation between the health of these watersheds and the supply and quality of water for the Salinas Valley.
- The Salinas Valley's population and economy are dependent on a long-term supply of high quality water from those watersheds, and on protection from floods.
- The reservoirs also provide ancillary benefits of recreation and habitat enhancement.

The communities around the reservoirs have an interest in insuring that the watersheds remain healthy. The land around San Antonio Reservoir, also known as Lake San Antonio, is located in Monterey County and is mostly owned by Monterey County. While Nacimiento Reservoir, also known as Lake Nacimiento, is located in San Luis Obispo County, it is managed by the Monterey County Water Resources Agency. About half of the land around Nacimiento Reservoir is owned by approximately 5,000 private owners who want to make sure the watersheds and reservoir remain healthy to protect property values and business interests that depend on the reservoir. Another reason to keep the watersheds healthy is that San Luis Obispo County will soon annually draw up to 17,500 acre feet of water from Nacimiento Reservoir as "raw" water to be treated and used as drinking water.

Source water supply and water quality are increasingly regulated by the State of California and the United States government. The MCWRA expects that trend to continue, while believing that locally based initiatives are preferable to regulatory actions imposed by higher levels of government. The MCWRA believes it should lead efforts to involve local landowners and other stakeholders in the watersheds to identify methods by which high quality water supplies can be maintained over the long-term, rather than merely react to studies and organizational efforts conducted by others.

B. How the Plan was Prepared

Following submittal of a watershed management plan grant request by MCWRA to the Regional Water Quality Control Board, MCWRA staff was invited to several community meetings in Lockwood. At these meetings, community members had the opportunity to ask about the purpose of a plan, what it might mean for property owners, and what the role of the MCWRA

and other government agencies already engaged would be in regards to plan development. A Steering Committee (SC) of stakeholders was formed who negotiated an agreement with MCWRA that the Steering Committee would have the final decision on how the plan was developed and that, if need be, local residents would have greater influence over decisions for the plan than other Steering Committee members and other stakeholder interests.

The Steering Committee then selected a facilitator for the process and a plan writer. MCWRA provided the necessary contracts for the facilitator and plan writer. The Steering Committee, Facilitator, and Plan Writer developed a Technical Advisory Committee (TAC). The SC and TAC were then facilitated to generate guidance for the staff team for the production of each of the work products described in the Executive Summary. The staff team generated agendas, meeting notes and draft documents for SC and TAC review. The staff team was comprised of the SC Co-chairs, Facilitator, Plan Writer and MCWRA Grant Administrator. Over the course of two years an extended dialog within the SC and TAC, as well as outside these committees through public review, led to the formulation of the Plan. A portion of the watershed area included in this Plan was previously covered by the Upper Salinas River Watershed Action Plan (2004).

NOTE TO READER: Quoted material from authors and sources compiled in the Watershed Resources Inventory and presented in the Nacitone Watersheds Management Plan is credited to the source, italicized and indented.

C. Vision Statement and Guiding Principles of the Nacitone Steering Committee

The Vision Statement developed by the Steering Committee acknowledges the importance of all uses of these watersheds.

The Nacimiento / San Antonio River Watersheds Management Plan should protect water quality and watershed uses for all stakeholders.

The following are guiding principles important for effective protection of water quality and watershed uses for all stakeholders.

- Manage human watershed uses and natural watershed resources and functions to co-exist over the long-term.
- Foster trust and a stewardship ethic among all watershed users.
- Encourage and facilitate voluntary and incentive-based efforts rather than additional regulation to protect water quality and watershed uses and functions.
- Protect the quality and quantity of surface water and ground water
- Seek to balance the use of watershed resources in order to protect those uses including homes and communities, infrastructure, farming, ranching, recreation, military, and others.
- Facilitate greater understanding within our communities of how watersheds function and how individuals, entities, and groups with jurisdiction can protect both watershed uses and watershed health.

D. Balancing Watershed Uses Through Thoughtful Communications

The Watersheds Management Plan recognizes the potential for competition among diverse demands on the natural resources and functions of these watersheds. It is important to understand and acknowledge the challenge of finding an equitable and effective way to balance the uses of watershed resources while protecting the critical natural functions of these watersheds that make the resources available. Water, soil, forests, other plant life and animal communities should be respected for their intrinsic worth as well as carefully used and managed for a variety of human uses such as the creation of homes, communities with infrastructure, recreational enjoyment of the resources, farming and ranching, support of military needs, etc.

The Plan attempts to summarize what is known about these watersheds, their uses and resources. The plan also lays the groundwork for improved communication and coordination across these uses and among watershed residents, government agencies, pertinent jurisdictions, and other watershed users.

There are several recommendations in this Plan to form water quality and watershed use-based, problem-solving roundtables. These roundtables would provide an opportunity for agencies responsible for managing watershed resources or uses to communicate with watershed users including landowners and others to clarify and understand varying mandates, voice concerns, assess available time, talents, and funding. A critical function of these roundtables would be to facilitate cooperative agreements for coordinated management of these watershed uses and the dissemination of information to the public.

Specific recommendations from the Steering Committee and others engaged in this planning process may include the establishment or continuation of roundtables such as the following:

- **Fire Safe Councils**
- **Livestock Grazing Coordinating Committee**
- **Lake Recreation and Public Safety roundtable**
- **Cross-county Land Use Planning Task Force**
- **Water Quality Information Sharing roundtable**
- **Community Road Associations**

Descriptions of these roundtables and the tasks envisioned for them are in the following chapters.

E. Water Quality and Watershed Health by Identifying and Preventing Impacts

Unfortunately, water quality and watershed uses can be threatened when watershed uses are not well managed or when naturally occurring conditions exist that negatively impact water quality or watershed health. Examples of naturally occurring conditions include total dissolved solids (TDS) and selenium in the San Antonio River. Increase in population (watershed usage) and new watershed uses requires the ability to improve protection measures, including the creation of innovative management measures. The Steering Committee has assessed and compiled existing information on current water quality and explored potential negative impacts arising from current uses in the watersheds.

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PART 2
Existing Conditions

The existing conditions section is a depiction of relevant descriptive data on the physical, natural and cultural resources of the Nacimiento and San Antonio River watersheds. This information is important to understand the context for water quality changes over time. To a large extent, the authors have relied on data and descriptions of resource conditions contained in prior reports. This information has been reviewed and incorporated into this section of the plan. The prior reports were not subjected to technical or peer review in preparing this plan.

In addition, the Steering Committee elected to have an independent analysis of water quality, water supply, erosion and sediment supply, and historic conditions of the channel and riparian corridor performed by an outside consultant, Swanson Hydrology and Geomorphology (SH+G). The product, Nacitone Watershed Resources Inventory Final Technical Memorandum—Water Resources, Water Quality and Sediment Supply, will be included with this report in Appendix D. Contents of the technical memorandum have been excerpted and integrated into the hydrology, water quality and reservoir features and management sections of Part 2.

It is anticipated that this information about existing conditions will serve as a baseline for future investigations in the watershed.

I. PHYSICAL FEATURES OF THE WATERSHED

A. Location, Overview and Topography

The Nacitone watersheds include the two adjacent watersheds trending southeast from the Santa Lucia Range to the Salinas River in San Luis Obispo and Monterey Counties (Figure 1). Comprised of the Nacimiento and San Antonio River watersheds, the term Nacitone originates from the Dust Bowl days when the US Soil Conservation Service formed the Nacitone Soil Conservation District.

Portions of the Nacimiento River and San Antonio River watersheds are located in San Luis Obispo and Monterey counties. Approximately 53% of the Nacimiento River watershed lies in San Luis Obispo County and almost 97% of the San Antonio River watershed lies in Monterey County. The headwaters of both the Nacimiento and San Antonio Rivers are located in the Los Padres National Forest. The San Antonio River watershed originates at an elevation of 3,060 feet above sea level and is characterized by a 'V-shaped' valley. The San Antonio River Valley consists of a series of northwest-southeast trending drainages with scattered brush, oak trees and relatively steep sides. In the eastern part of the watershed, Jolon Valley merges with Lockwood Valley and forms an area characterized by a large, relatively flat, southeasterly sloping surface (Geotechnical Consultants, Inc, 1984). The Nacimiento River watershed originates at an elevation of approximately 3,350 feet above sea level and its valley is also characterized by a 'V-shaped' valley.

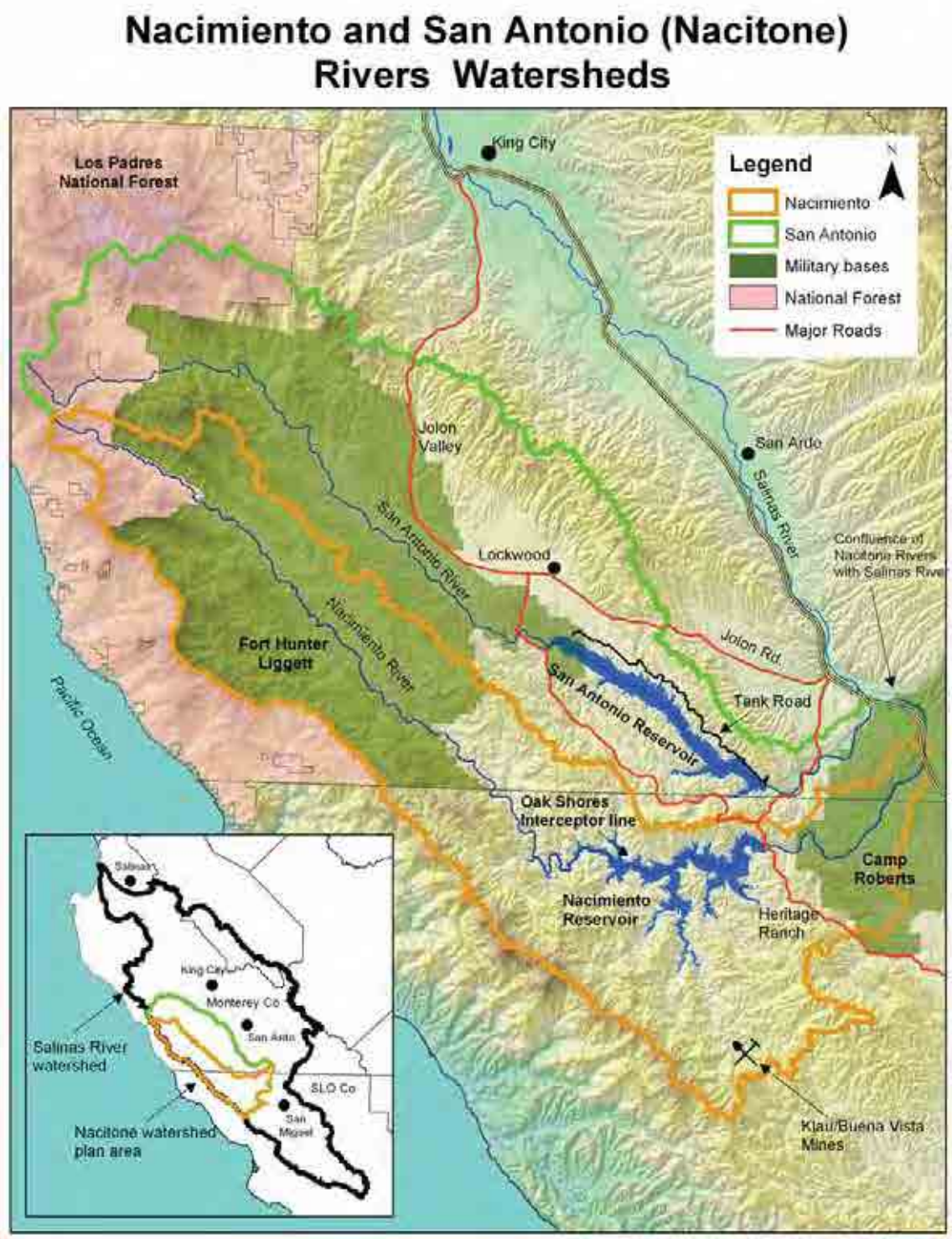

Figure 1. Nacimiento and San Antonio River Watersheds

Watersheds Description

The Nacimiento and San Antonio River watersheds cover 705.3 square miles from the ridges within the Santa Lucia Range to each river's confluences with the Salinas River. The Monterey County Water Resources Agency has estimated the San Antonio River watershed to contain

343.8 square miles or 220,003 acres and the Nacimiento River watershed is 361.5 square miles or 231,373 acres (Ken Ekelund, 2007). Both watersheds are impounded creating reservoirs. The San Antonio River is impounded at river mile 5 and the Nacimiento River is impounded at river mile 10. The reservoirs are operated by the Monterey County Water Resources Agency and both are managed as a unit for the control of seawater intrusion, groundwater recharge and groundwater quality enhancement for the Salinas Valley, recreational opportunities for the adjoining and regional communities, flood control, drought protection, and preservation of aquifer storage (RMC, 2003). Nacimiento Reservoir began operating in 1957 and San Antonio Reservoir in 1965 (Montgomery Watson, 1997). The drainage area controlled by the two dams is approximately 650 square miles .

Although adjacent watersheds, Nacimiento and San Antonio are very different geologically and metereologically, which affects how each functions hydrologically. These differences have led to the framework upon which the reservoirs are managed. Management, in turn greatly influences existing watershed conditions. The Nacimiento River watershed, although only slightly larger, receives much higher rainfall than the San Antonio River watershed, and experiences more runoff due to its higher rainfall and geologic features. Because of these features, Nacimiento Reservoir fills more quickly. The San Antonio watershed generates less runoff due to both lower rainfall and the storage of rainwater as groundwater in an alluvial basin situated upstream of the San Antonio Reservoir. A steering committee discussion occurred regarding safe yield of the watersheds above their respective dams. Safe yield is a term used to express the amount of water an aquifer or well can yield for consumption without producing unacceptable negative effects. Safe yield information is not available for these watersheds.

Watershed Features

San Antonio River Watershed

The San Antonio River has its headwaters in the Santa Lucia Mountains between Cone and Junipero Serra peaks, in the Ventana Wilderness of Los Padres National Forest. The stream flows in a southeasterly and easterly direction through the Los Padres National Forest and Fort Hunter Liggett Military Base (FHL) to its confluence with the Salinas River. The river is 58.2 miles in length, of which the first 8.6 miles of the south fork and 6.7 miles of the north fork are located within the Los Padres National Forest. With the exception of the upper section including the headwaters, the drainages are normally dry during late summer and fall months, with the exception of Mission Creek, which historically has exhibited surface flow year-round. Spring-fed water flows through the upper portion of the San Antonio River throughout the year, while lower reaches have intermittent flow. San Antonio waterways include Carrizo Creek, Santa Lucia Creek, lower Rattlesnake Creek, Mission Creek, and Sulphur Spring (Las Tablas Creek and Lake Nacimiento TMDL, 2003)(Figure 2).

Nacimiento River Watershed

The Nacimiento River, located about five miles southwest of the San Antonio River, originates in the Santa Lucia Mountains south of Cone Peak, also within the Ventana Wilderness of Los Padres National Forest. The stream also flows southeasterly through the Los Padres National Forest, FHL and Camp Roberts and a few private parcels as well as the Nacimiento reservoir before it reaches its confluence with the Salinas River. The river is 54.2 miles in length of which 9.5 miles are located within the Los Padres National Forest. With the exception of the upper section including the headwaters, much of the Nacimiento River surface remains dry during

the summer. However, year round water can be found in various pools along portions of the river (FHL Special Resource Study, 2006).

Nacimiento River drainages can be divided into two groups: the lower basins that drain directly to the reservoir, and the upper basins that drain to the Nacimiento River, which then flows into the reservoir. The lower basins include Las Tablas, Franklin, Town, Dip, Snake, and Kavanaugh creeks. The upper basins include Little Burnett, Tabacco, Salmon, Las Berros, San Miguel, Stony, El Piojo, Waller, and Sapaque Creeks. The crest of the Santa Lucia Range forms the southwestern boundary of the Nacimiento River watershed, and the San Antonio River watershed divide bounds it on the northeast (Clean Lakes Assistance Program for Lake Nacimiento, 1994). Additional main stem creeks include: Carrals Spring, Slickrock Creek, Stony Creek, San Miguel Creek, Upper Los Berros Creek, N. Fork Los Burros Creek, San Miguelitos Ranch, Gabilan Creek, Los Bueyes Creek, Lower Los Burros Creek, Oak Flat, Waller Creek, Mesa Coyote, Pozo Honda Creek, Turtle Creek and Gulch House Creek (Las Tablas Creek and Lake Nacimiento TMDL, 2003)(Figure 2).

Figure 2. Nacimiento and San Antonio River Subwatersheds

B. Geology

The significance of geology to an understanding of watershed health relates to the physical changes that occur based on the underlying rock structures, their constituent elements and their juxtaposition within the watershed. Geologic information was derived from previously published sources collected for the WRI. Figure 3 was produced by SH+G for this project.

San Antonio River Watershed

The San Antonio River Watershed lies within Salinian Block of the Pacific plate. The Lockwood basin occupies a valley in southwestern Monterey County between the Santa Lucia range to the west and the Lockwood-San Ardo hills to the east. The Los Ojitos Hills form the southern boundary.

Marine sediments of Miocene age are assigned to the Vaqueros, Monterey and Santa Margarita formations. Overlying a granitic basement, they are as thick as 825 feet in the west and thin to the east. The Monterey Formation progressively truncates the Vaqueros in an easterly direction.

The youngest sandstone of the Miocene sequence is referred to as the Santa Margarita Formation. Of these units, only the Monterey Formation crops out in the Lockwood area. It forms the bulk of the Lockwood-San Ardo hills and is extensively exposed in the hills southwest of the San Antonio River (Logan, 1987).

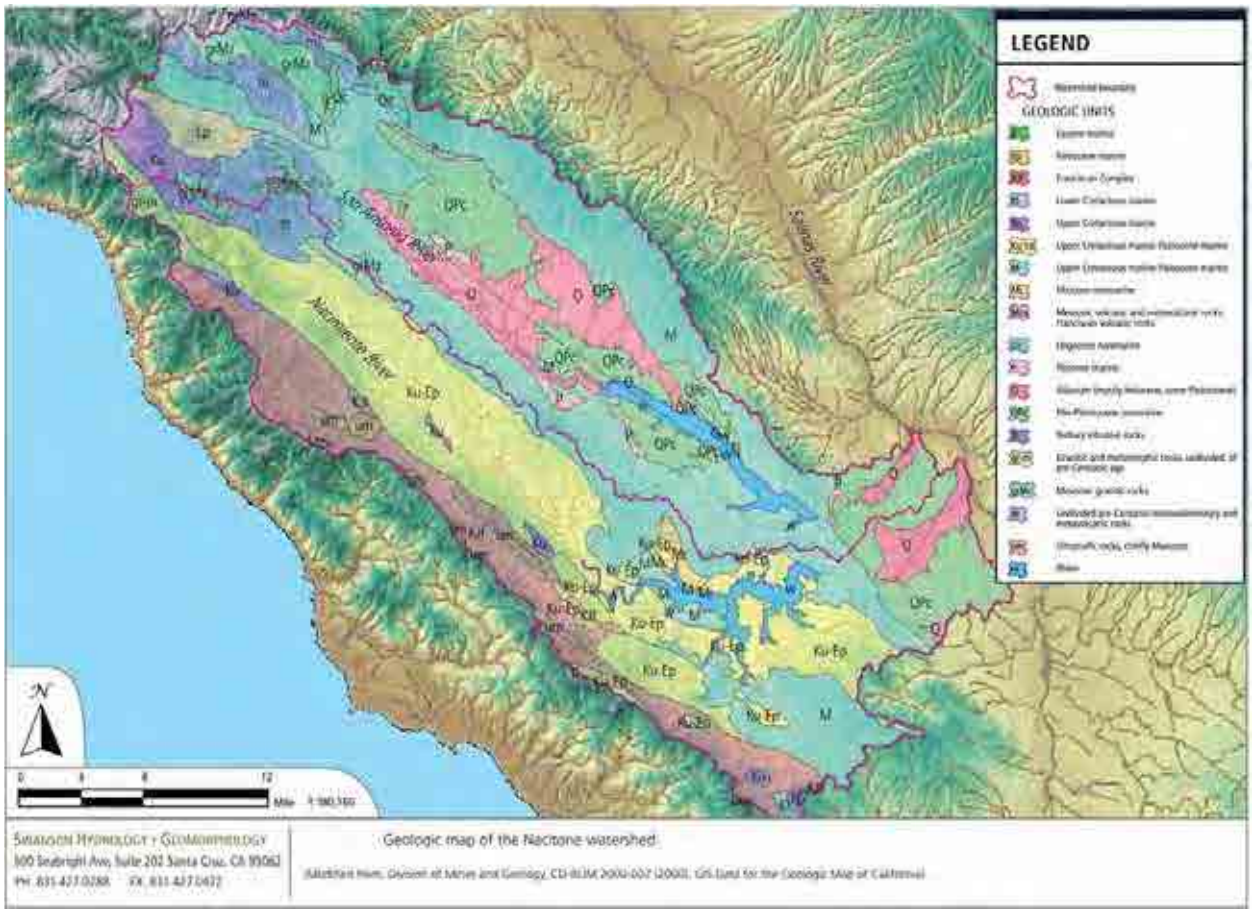

Figure 3. Geologic map of Nacitone watersheds

Nacimiento River Watershed

The Nacimiento River watershed lies within Salinian Block of the Pacific plate. The Salinian Block, which is bounded on the east by the San Andreas Fault Zone and is underlain at depth by a basement of extensively folded and faulted Franciscan rocks of Jurassic age. Sedimentary rocks of Cretaceous to Late Tertiary age are commonly exposed at the surface in this province and are extensively folded and faulted. Pleistocene and recent sediments are offset along the San Andreas Fault (NWP EIR, 2003).

Paso Robles Formation – The nonmarine, Plio-Pleistocene-age Paso Robles Formation consists of massive to locally cross-bedded, poorly exposed, weakly consolidated mixtures of gravel, sand, silt, and clay.

Santa Margarita Formation – The Miocene-age, Santa Margarita Formation predominantly consists of poorly stratified, sandy, marine sediments that conformably overlie the Monterey Formation and are locally unconformably overlain by the Paso Robles Formation. The arkosic sandstone of this formation is typically massive to coarsely crossbedded and locally contains abundant shell beds and reefs. The thickness of the Santa Margarita Formation ranges from approximately 200 feet west of Atascadero to a maximum of 2,000 feet northeast of Santa Margarita.

Monterey Formation – The Miocene-age Monterey Formation consists of well-bedded, marine, siliceous and calcareous shale. That shale includes interbeds of chert along with diatomaceous, porcelaneous, tuffaceous, and dolomitic units. Local interbeds of sandstone are also present within an upper member of that formation, where distinguishable. The shale ranges in thickness from approximately 200 feet to more than 2,000 feet.

Tierra Redonda Formation – The Miocene-age Tierra Redonda Formation consists of nonfossiliferous, thickly bedded to massive sandstone located southwest of the Jolon fault. That formation locally is composed of granitic boulder conglomerate with clasts ranging in size from 1 to 8 feet in greatest dimension. The Tierra Redonda Formation conformably overlies the Vaqueros Formation and intertongues with the Sandhodt Member of the Monterey Formation. The Tierra Redonda Formation has a thickness of approximately 1,650 feet in the type area.

Unnamed Tertiary/Cretaceous Unit – This unit is located west of Paso Robles, specifically southwest of the Jolon fault, and consists predominantly of sandstone and conglomerate with locally abundant mudstone. The thickness of this unit is unknown because the base of the unit is obscured; however, the unit is at least 2,500 feet thick.

Franciscan Formation – The Franciscan Formation consists of a mélange of sandstone, mudstone, and greenstone, with lesser amounts of chert, serpentinite, diabase gabbro, and blueschist facies metamorphic rocks. Those materials are thinly bedded to massive, locally highly fractured and discontinuous, and poorly to well indurated. Serpentinite-rich zones withinmthe Franciscan Formation may locally contain a magnesium-silicate mineral called chrysotile. Chrysotile typically occurs in veins of silky fibers and is an important source of commercial asbestos (NWP EIR, 2006).

Information on soil and vegetation types is briefly discussed in Appendix C (Agency Grazing Land Management Plan). Appendix C includes soil and vegetation information for Agency Grazing leases around both reservoir. More detailed information for other location in these watersheds can be obtained from the Natural Resources Conservation Service in either Monterey or San Luis Obispo counties.

II. DESCRIPTION OF CURRENT CONDITIONS OF THE WATERSHED

The current conditions section is a depiction of relevant descriptive data on the natural and cultural resources of the Nacimiento and San Antonio River watersheds. Status and reference information from the Watershed Strategy section of the plan may be in part repeated here and expanded in more detail.

A. HYDROLOGY

Hydrology is defined as the study of water and its properties, including its distribution and movement in and through the land areas of the earth. Understanding the hydrology of these watersheds is important to understanding water quality and quantity changes over time.

Surface Water

The Nacimiento and San Antonio Rivers together contribute more than 75 percent of the flow of the Salinas River at Monterey Bay (Clean Lakes Assistance Report, 1994), specified in acre-feet that is approximately 200,000 acre-feet per year (AFY) and 70,000 AFY to the Salinas River, respectively. In order to maintain minimum flow requirements in the river channels below the Nacimiento and San Antonio dams, a 25 cubic feet per second and 3 cubic feet per second flow requirement at the site of the dams, respectively, is required (SVWP EIR, April 2002).

The average annual inflow to Nacimiento Reservoir is about three times that of San Antonio Reservoir, on average. The MCWRA has operated the reservoirs so that releases from the two reservoirs also maintain an approximate 3:1 ratio in stored water between the reservoirs. Pursuant to the Nacimiento Dam Operation Policy (MCWRA, 2000), whenever possible, a release schedule is to be adopted that results in an empty space being created in the Nacimiento Water Conservation Pool that is three times that of the San Antonio Water Conservation Pool empty space on November 1st of each year.

SH+G prepared a water budget to analyze the available surface water supply. A water budget reflects the relationship between input and output of water through a region The water budget for the Nacitone watersheds takes into account all aspects of the hydrologic cycle as well as the operational aspects of the Nacimiento and San Antonio Reservoirs (discussed below in Reservoir Features and Management). Graphic representation of the water budgets is provided in (Figures 4, 5 & 6). This information can be used by stakeholders as they work together to protect beneficial uses of the watershed as well as in meeting the MCWRA interests of groundwater recharge targets for the Salinas Valley.

Lake Nacimiento Watershed

	Before Reservoir [volumes in af]		→	Reservoir [volumes in af]					
Water Year	Precipitation	ET + Groundwater Recharge	Runoff[1] + Reservoir	Oct. 1 Reservoir Capacity	Direct Precipitation	Evaporation	Dam Release	Direct Diver. Precipitation[2]	Net Change in Storage
1959	267,134	152,903	114,231	250470	4,400	16,623	231,874	30,170	-160,035
1960	302,935	212,486	95,400	90435	5,071	8,730	155,232	16,088	-79,580
1961	289,241	242,437	51,513	10855	4,842	4,777	35,764	10,713	5,100
1962	575,476	244,329	340,515	15955	9,633	13,492	159,981	80,739	95,935
1963	578,816	276,048	312,190	111890	9,689	16,368	135,769	54,992	114,750
1964	338,673	271,974	72,212	226640	5,669	13,846	214,326	11,498	-161,790
1965	419,500	193,353	232,976	64850	7,022	13,717	144,220	39,736	42,325
1966	398,792	223,821	181,463	107175	6,675	14,526	171,493	-17,426	19,545
1967	819,982	290,323	542,987	126720	13,725	17,168	280,600	155,120	103,825
1968	265,527	229,075	40,775	230545	4,445	14,376	189,614	13,834	-172,605
1969	1,052,089	324,223	744,993	57940	17,611	11,722	622,366	131,055	-2,540
1970	299,595	87,526	216,946	55400	5,015	10,907	134,225	58,048	18,780
1971	364,056	186,964	183,019	74180	6,094	12,428	149,911	43,014	-16,240
1972	255,507	189,622	70,044	57940	4,277	7,280	83,187	8,719	-24,885
1973	782,514	272,049	502,878	33075	12,764	16,853	168,934	128,251	201,603
1974	575,142	223,833	360,671	234678	9,627	19,886	255,201	82,364	12,847
1975	375,412	18,875	362,648	247525	6,284	19,849	238,149	117,414	-6,480
1976	309,281	302,143	12,173	241045	5,177	15,795	179,080	-629	-176,895
1977	252,167	248,166	8,106	64150	4,221	6,492	44,055	2,620	-40,840
1978	850,021	93,231	770,828	23310	14,228	18,135	306,803	231,838	228,080
1979	470,601	295,526	182,736	251390	7,877	20,686	184,665	-20,966	6,248
1980	658,975	220,205	449,498	257638	11,030	18,086	360,145	96,211	-13,923
1981	372,072	276,734	101,395	243715	6,228	19,245	167,667	11,061	-90,350
1982	526,049	198,709	337,935	153365	8,839	18,379	138,881	51,420	138,095
1983	876,073	10,545	879,790	291460	14,664	17,653	733,710	200,626	-67,435
1984	285,233	156,425	133,451	234025	4,774	17,342	215,885	6,194	-101,205
1985	310,283	209,138	106,196	132820	5,194	12,964	165,620	17,286	-84,480
1986	571,134	165,391	415,040	48340	9,560	17,596	142,360	62,285	202,360
1987	246,155	201,725	48,438	250700	4,120	17,861	133,575	-1,542	-97,335
1988	461,249	417,072	51,686	153365	7,721	12,808	161,173	1,231	-115,805
1989	311,953	270,994	46,037	37560	5,222	4,639	88,267	4,563	-26,210
1990	241,146	224,030	21,042	11350	4,036	4,479	5,538	1,161	13,900
1991	464,255	324,522	147,291	25250	7,771	9,929	87,886	31,559	25,688
1992	479,285	346,658	140,230	50938	8,023	10,054	116,420	14,222	7,557
1993	837,663	372,993	478,306	58495	14,021	16,761	267,227	104,270	104,069
1994	382,426	324,115	64,537	162564	6,401	11,812	158,767	17,108	-116,749
1995	997,314	527,899	485,650	45815	16,694	18,209	190,776	51,919	241,440
1996	459,579	217,104	249,956	287255	7,693	20,950	321,352	-2,484	-82,169
1997	586,164	216,394	379,312	205086	9,812	17,693	462,615	-35,348	-55,836
1998	894,109	271,346	637,316	149250	14,966	18,218	379,448	101,215	153,403
1999	312,955	197,166	120,883	302653	5,238	19,361	151,339	26,441	-71,020
2000	441,209	187,985	260,406	231633	7,385	18,976	206,291	56,257	-13,733
2001	515,357	358,521	165,225	217900	8,626	19,047	142,558	26,625	-14,378
2002	277,885	196,407	86,002	203522	4,651	15,881	155,732	15,387	-95,347
2003	459,579	263,424	203,637	107175	7,693	15,659	127,765	31,025	36,860
2004	317,631	224,796	98,005	144035	5,317	14,510	112,076	16,196	-39,460
2005	938,530	456,155	497,653	104575	15,710	19,677	229,170	94,751	169,765
2006	519,365	205,700	322,119	274340	8,694	23,731	214,143	88,107	4,830

[1]Runoff was estimated using daily USGS gage data which may underestimate large flows.

[2]Direct use, percolation and other losses were both calculated using rainfall data and other known parameters, which may produce the occasional negative value.

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Water budget for the Lake Nacimiento watershed and reservoirs.

Figure 4. Water Budget Table for Lake Nacimiento Watershed (post dam construction)

San Antonio Watershed

	Before Reservoir [volumes in af]		→	Reservoir [volumes in af]					
Water Year	Precipitation	= Groundwater Recharge	Runoff[1] → Reservoir	Oct. 1 Reservoir Capacity	Direct Precipitation	Evaporation	Dam Releases	Direct Use + Percolation[2]	Net Change in Storage
1967	807,493	617,941	189,552	20475	11,352	10,711	2,102	69,136	110,495
1968	261,490	245,541	15,949	130970	3,676	13,834	7,176	-2,346	-1,425
1969	1,036,091	737,808	298,282	129545	14,586	20,891	31,698	77,091	177,580
1970	295,039	216,589	78,450	307125	4,148	23,026	76,487	47,437	-64,645
1971	358,520	311,321	47,199	242480	5,040	19,300	15,523	19,303	-2,625
1972	251,622	240,523	11,099	239855	3,538	16,972	142,217	-1,875	-144,025
1973	750,919	579,579	171,340	95830	10,557	14,457	10,580	56,670	94,995
1974	566,396	412,406	153,990	190825	7,963	19,254	4,104	75,168	61,625
1975	369,704	246,102	123,602	252450	5,198	21,140	23,478	49,323	35,205
1976	304,578	300,203	4,375	287655	4,282	19,721	45,717	-3,778	-54,217
1977	248,333	248,327	5	233438	3,491	13,250	188,733	-16,655	-183,288
1978	837,096	508,963	328,132	50150	11,769	15,626	34,360	107,057	176,780
1979	463,445	383,594	79,851	226930	6,516	19,162	18,902	31,220	16,430
1980	648,955	442,916	206,039	243360	9,124	20,474	73,043	75,445	45,558
1981	366,414	322,017	44,398	288918	5,151	21,059	38,696	9,606	-20,498
1982	520,019	384,132	135,887	268420	7,311	19,252	65,300	49,471	8,180
1983	862,751	372,546	490,205	276580	12,129	18,969	116,340	361,369	7,105
1984	280,896	213,653	67,243	283685	3,949	20,383	65,769	24,389	-60,855
1985	305,565	276,254	29,311	222830	4,296	17,054	20,319	18,479	-23,480
1986	562,449	272,896	289,554	199350	7,807	18,435	62,418	148,328	67,410
1987	242,412	215,257	27,156	266760	3,408	18,216	74,245	-4,206	-57,695
1988	454,235	433,222	21,013	209065	6,386	15,954	49,716	10,374	-51,002
1989	307,209	292,661	14,548	158063	4,319	10,255	145,269	-992	-138,243
1990	237,479	232,791	4,688	19820	3,339	3,227	2,154	1,270	-1,397
1991	457,196	410,212	46,984	18423	6,428	4,403	21,731	16,205	5,527
1992	471,997	425,336	46,661	23950	6,636	4,997	16,794	13,654	12,457
1993	824,926	620,611	204,315	36407	11,598	11,247	15,677	75,934	105,043
1994	376,611	361,309	15,302	141450	5,295	10,704	83,468	2,109	-78,130
1995	982,148	725,354	256,794	63320	13,808	11,959	25,859	84,472	139,250
1996	452,591	325,433	127,158	202570	6,363	17,499	35,887	52,780	26,020
1997	577,251	357,418	219,832	228590	8,116	16,780	71,207	159,046	-22,030
1998	880,513	571,885	308,627	206560	12,379	16,914	25,020	193,130	83,115
1999	308,196	267,247	40,949	289675	4,333	18,651	29,802	17,214	-21,015
2000	434,500	327,494	107,007	268660	6,109	20,812	29,276	46,975	15,025
2001	507,520	444,049	63,471	283685	7,135	19,377	24,016	24,153	2,228
2002	273,660	231,202	42,458	285913	3,847	18,308	89,155	24,933	-86,563
2003	452,591	381,253	71,338	199350	6,363	15,641	28,427	13,351	18,600
2004	312,801	273,468	39,333	217950	4,398	13,713	NO DATA	111,278	-82,782
2005	924,259	701,625	222,634	135168	12,984	17,056	NO DATA	93,938	118,182
2006	511,467	349,826	161,641	253350	7,191	24,574	17,296	69,802	56,950

[1]Runoff was estimated using daily USGS gage flow which may underestimate large flows

[2]Some use, percolation and other losses were back-calculated using rainfall data and other known parameters, which may affect the results

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Water budget for the Lake San Antonio watershed and reservoirs.

Figure 5. Water Budget Table for Lake San Antonio Watershed (post dam construction)

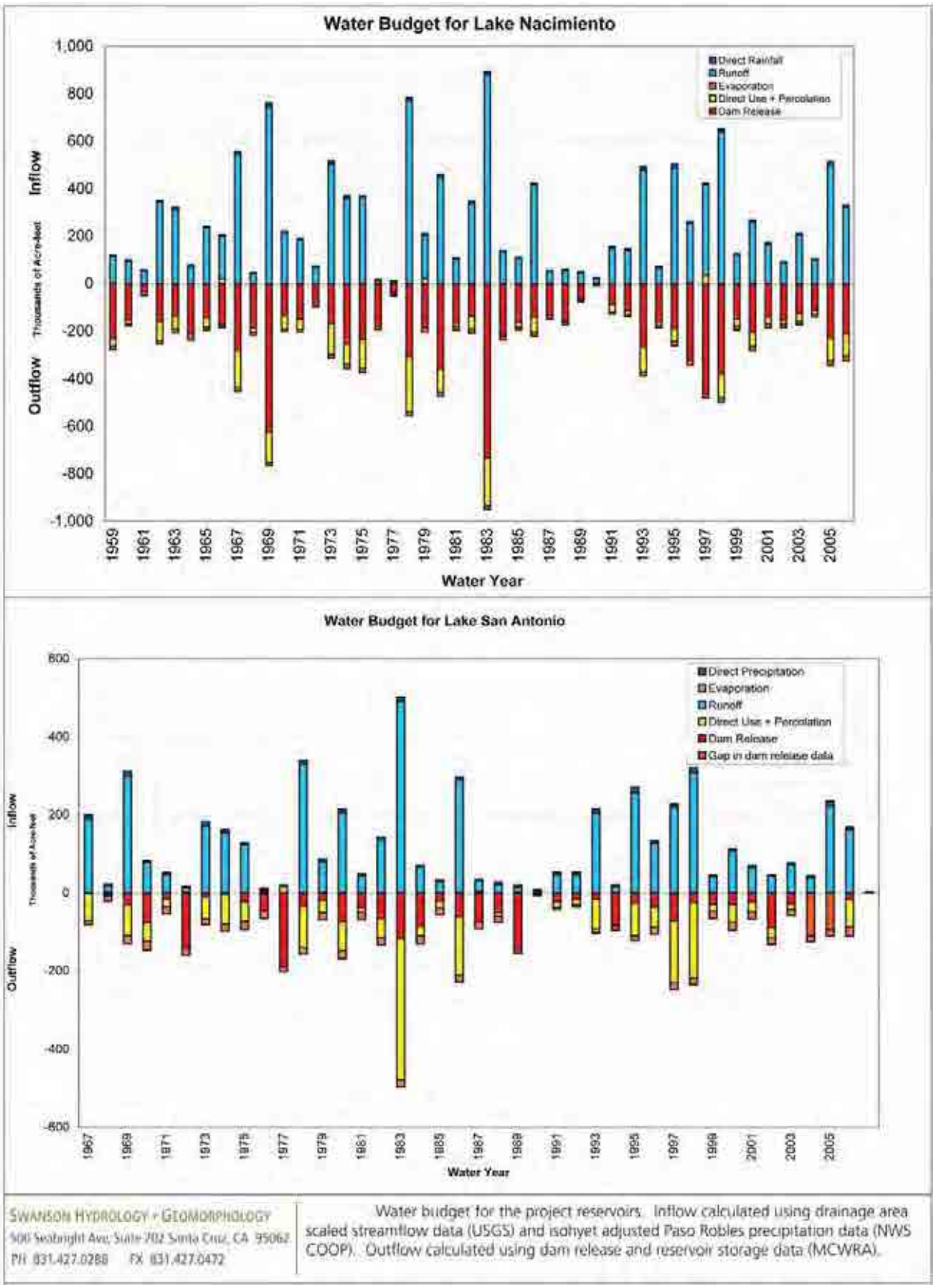


Figure 6. Graphic Water Budget for Lakes Nacimiento and San Antonio

Groundwater

The groundwater basins underlying the Nacitone watersheds include parts of the Paso Robles and Lockwood Groundwater Basins (Figure 7). The groundwater basins do not neatly underlie the watersheds' surface waters but instead conform to geologic features of the landscape. Examining these groundwater basins permits an understanding of the Nacitone water budget of the watersheds for consideration of overall water availability over time.

While it is the main groundwater basin within the Nacitone area, the Lockwood Valley Groundwater Basin is the least studied of the two primary groundwater basins that occur within the Nacitone Watersheds study area. The other two are parts of the Paso Robles Groundwater Basin and the Salinas Groundwater Basin. The Paso Robles Basin has been studied extensively by Fugro as part of a two-phase analysis of the basin (Fugro West, 2002; Fugro West et al, 2005). Similarly, extensive analysis of the Salinas Groundwater Basin, which historically experienced overdraft conditions and seawater intrusion, resulted in development of Nacimiento and San Antonio Reservoirs to provide winter storage of rains that are released during the dry season to recharge Salinas basin aquifers and limit seawater intrusion into the lower Salinas Valley near Salinas.

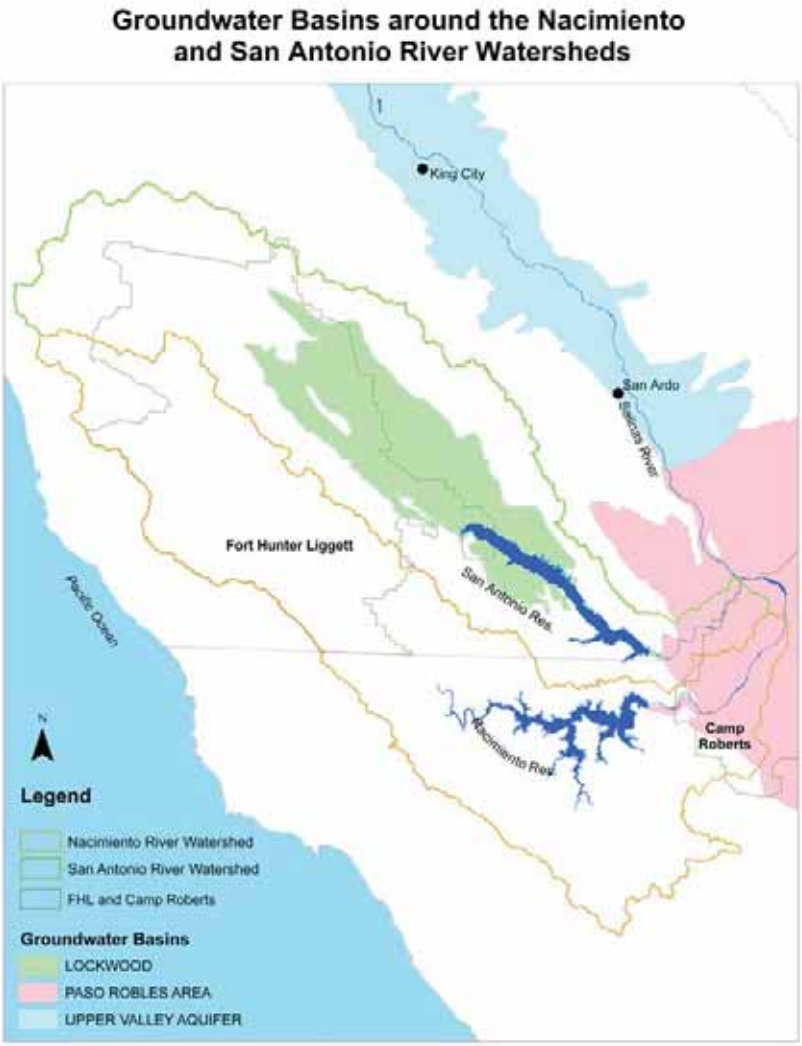


Figure 7. Groundwater Basin Map
Source: DWR GIS layer B118vNAD27UTM10

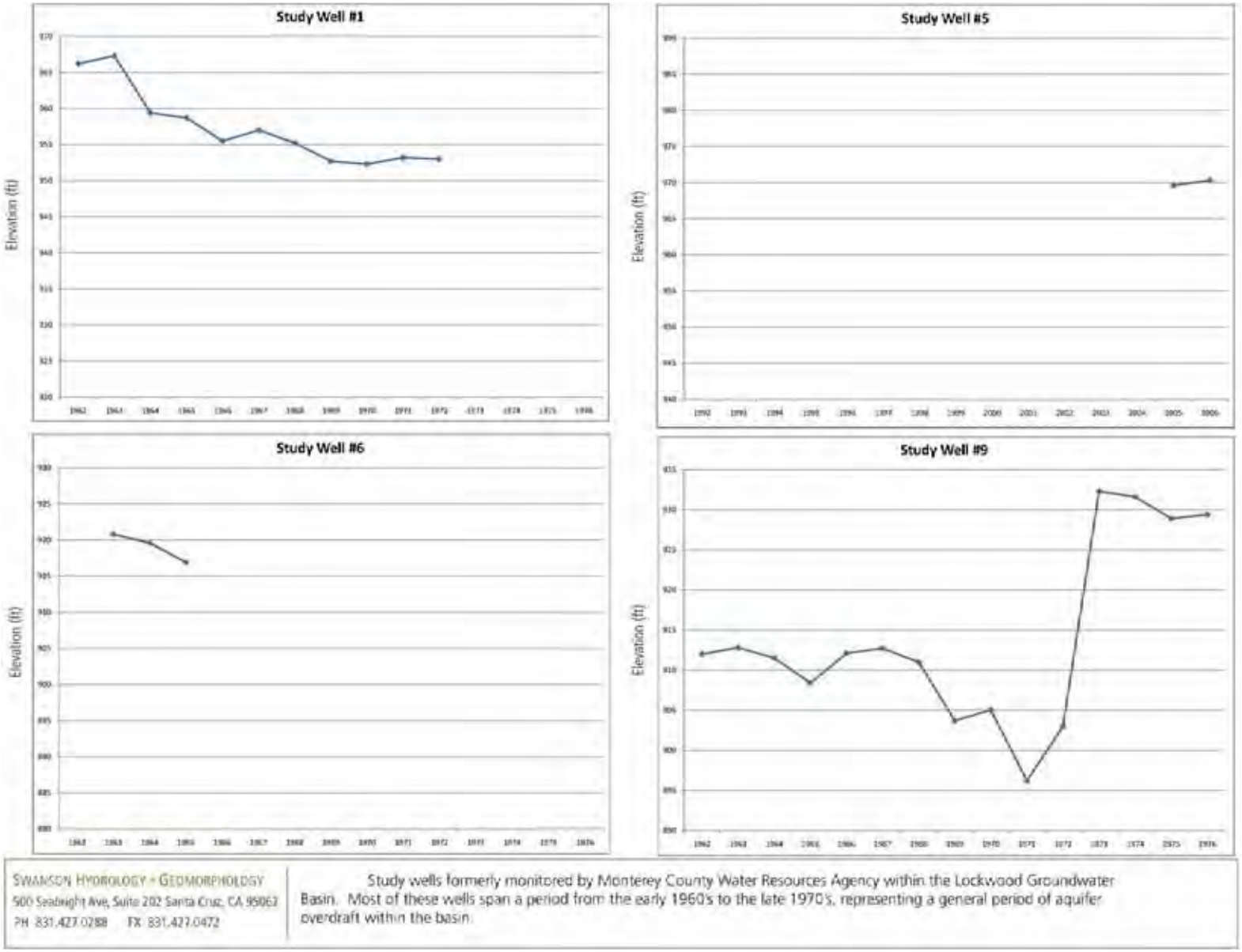
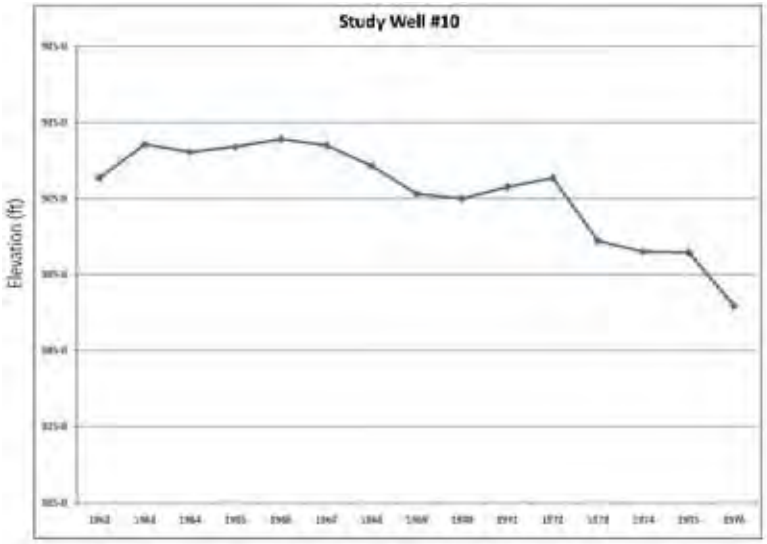


Figure 8a. Study Wells in the Lockwood Groundwater Basin, 1960-1979



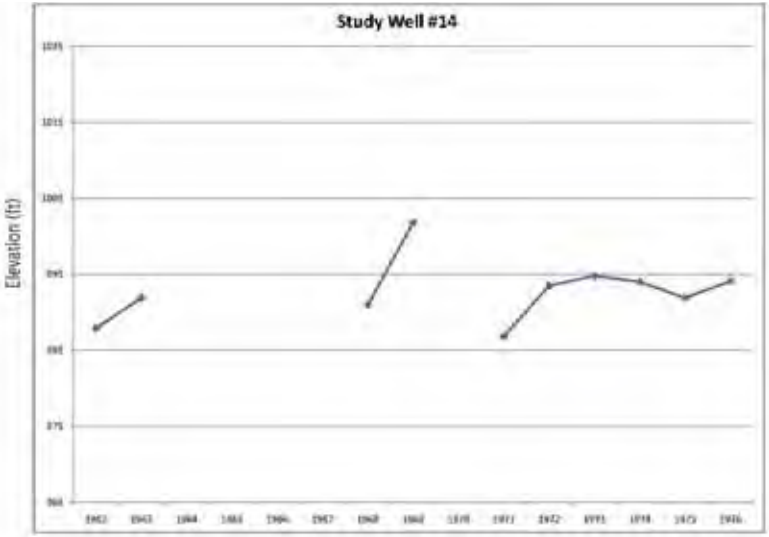


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Figure 8b. Study Wells in the Lockwood Groundwater Basin, 1960-1979

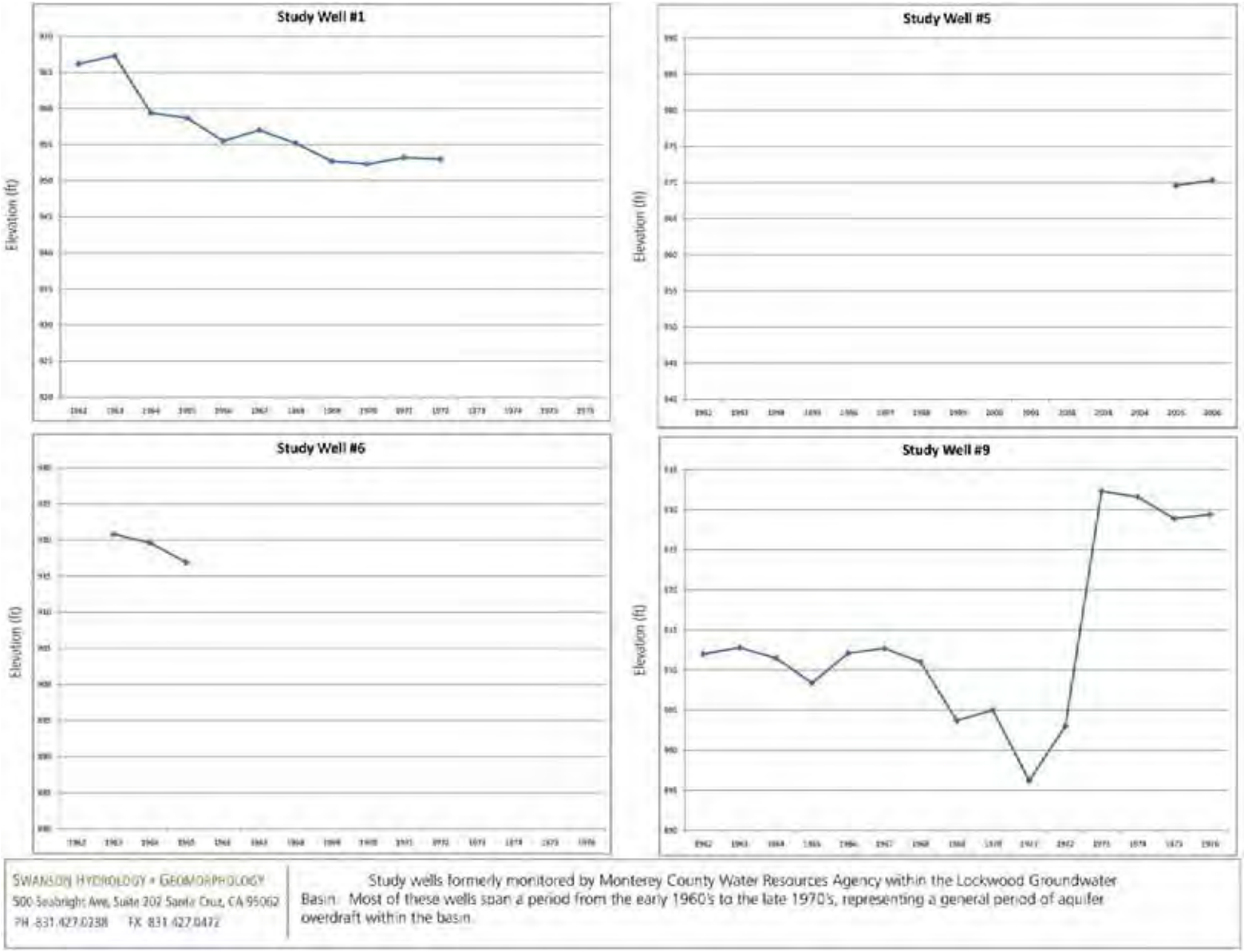


Figure 9a. Study Wells in Lockwood Groundwater Basin, 1960-present

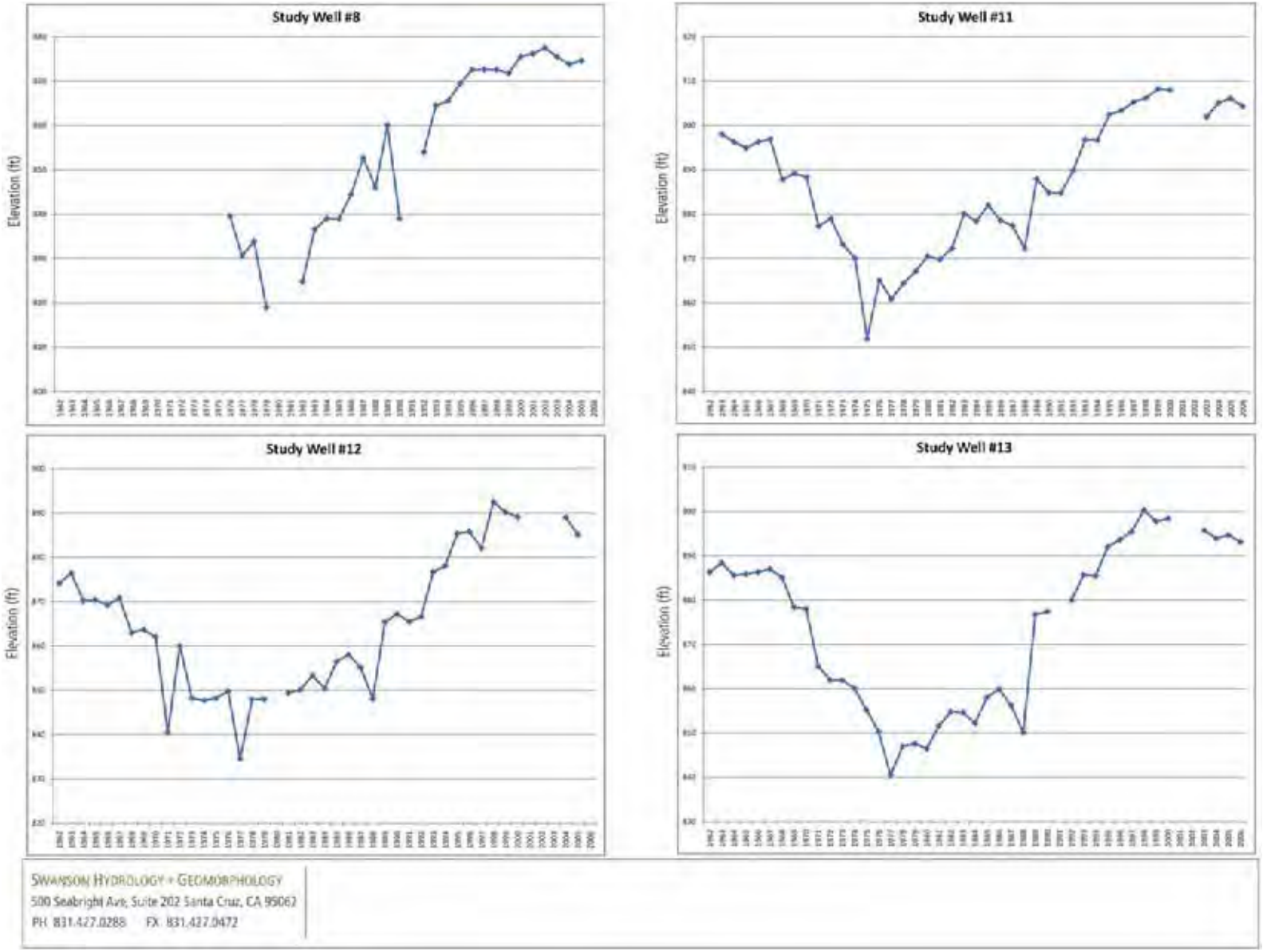


Figure 9b. Study Wells in Lockwood Groundwater Basin, 1960-present

B. Vegetation and Habitat

Descriptions of the Nacitone watersheds' habitats and vegetation are provided as gleaned from WRI information (For more detailed information, please refer to WRI Analysis posted at www.nacitonewater.org.) As the basis for much of watershed function, vegetation and habitats includes special status species and habitats within the watersheds that possess characteristics considered special by various jurisdictions.

Headwaters

Los Padres National Forest and the Ventana and Silver Peak Wilderness

The upper watersheds of the Nacimiento and San Antonio Rivers consist of remote undeveloped wildland with deep canyons and mountain peaks approaching 6000 ft which are part of the geologically complex Santa Lucia Mountains. Marked vegetation changes partition the watersheds into well-defined ecosystems. Much is chaparral with grass meadows, oak woodlands, pine forests and stunning rock formations creating a mosaic across the rugged landscape.

The Cone Peak Gradient Research Natural Area is located near the source of the Nacimiento River and is an area unusual for its ecological diversity and presence of the rare Santa Lucia Fir. The Valley Oak Research Natural Area is located on the North Fork of the San Antonio River and has one of the few remaining examples of valley oak woodland on public lands in California. Other vegetation types within the area include blue oak woodlands, California annual grasslands, chamise chaparral, coastal sage scrub, and riparian vegetation along the San Antonio River (USDA-Land Management Plan Part 2 Los Padres National Forest Strategy, Sept. 2005).

A review of the WRI documents revealed that the ecologically diverse landscape of the watersheds supports a variety of threatened and endangered species including the Arroyo Toad, Western Pond Turtle, Red-legged frog and the California Condor. The area also supports populations of mountain lion, bobcat, fox and deer.

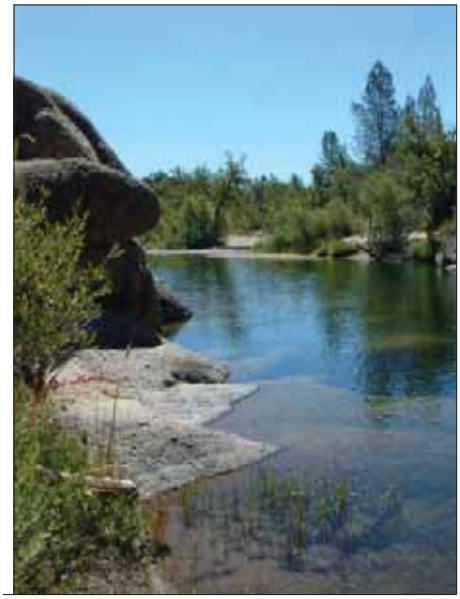


Figure 10. River Upstream of Nacimiento Reservoir (Source: USLT RCD)

Redonda Mountain Sensitive Resource Area

Tierra Redonda Mountain is a major landmark in the planning area, and this broad table-top mountain encompasses approximately 1,300 acres with 320 acres under Bureau of Land Management (BLM) ownership. The mountain is of outstanding ecological importance and has been given a high priority for preservation by the State Department of Parks and Recreation. Most of the public lands are generally designated for open space use only. The San Luis Obispo County Land Use Ordinance indicates that emphasis should be placed on maintenance of the entire mountain as an undisturbed ecosystem rather than several small isolated preserve areas. Uses should be carefully regulated because of fire hazard problems and potential damage to fragile ecosystems (Oak Shores EIR, 2007).

Fort Hunter Liggett

The number of rare and sensitive plant species on FHL is among the highest for similar sized areas in California. This diversity of species can be attributed to the well-preserved landscape and unique geologic resources that underlie FHL. FHL encompasses extensive oak woodland and savanna communities, including valley oak, blue oak, coast live oak and native grassland under story vegetation. It offers the widest diversity of oak taxa of any area of its size in California. Oak woodlands and savanna on FHL include the largest known contiguous valley bottom stands of valley oak. The native oak savanna provides important habitat for many rare, threatened, and endangered species, including purple amole, Tule elk and San Joaquin kit fox. FHL has the highest concentration of oak savanna-specializing birds of any location in the nation.

Chaparral, vernal pools and riparian areas are additional rare habitat types on FHL that support nationally significant species. (FHL Special Resource Study, NPS, 2006).

Valley oak woodlands, valley needlegrass grasslands, and sycamore alluvial woodlands occur on FHL and are considered special status communities by CDFG. Special status communities are defined as biological communities that are rare or restricted in occurrence, provide important habitat for wildlife and unusual plant assemblages, or are jurisdictional waters or wetlands of the United States. Additional valuable communities on FHL include wetlands, riparian communities, oak woodlands and savannas, native bunch grass (especially valley needlegrass) grasslands, and rock outcrops. Section 7.6 through 7.12 of the FHL Integrated Natural Resources Management Plan (INRMP) includes Plant communities, threatened, endangered and other sensitive species, game species, fisheries, non-game species, migratory birds and exotic/invasive plants and wildlife.

Plant Community	San Antonio Watershed			Nacimiento Watershed		
	ha	ac	% of watershed	ha	ac	% of watershed
Grasslands	4299	10623	13	2508	6196	8
Oak woodlands and savannas						
Valley oak woodland	636	1571	2	727	1796	2
Valley oak savanna	2596	6415	8	2986	7378	9
Blue oak woodland	10690	26415	32	7835	19362	24
Blue oak savanna	1714	4235	5	1073	2652	3
Coast live oak woodland	577	1427	2	146	360	0.5
Coast live oak forest	547	1351	2	804	1987	2
Chaparral						
Mixed chaparral	3868	9559	12	10905	26947	33
Chamise chaparral	6274	15503	19	4928	12177	15
Riparian						
Mixed riparian	1263	3121	4	276	681	1
Willow riparian	3	7	0.01	2	4	0.01
Cottonwood riparian	0	0	0	62	153	0.2
Valley oak riparian	12	28	0.03	16	40	0.05
Sycamore riparian	2	6	0.01	273	674	1
Seasonal and perennial wetlands						
Vernal pool	11	26	0.03	0	0	0
Vernal swale	135	334	0.4	0	0	0
Wet meadow	59	146	0.2	63	155	0.2
Pond	37	91	0.1	43	106	0.1
Developed areas	150	371	0.5	0	0	0
Unclassified	78	194	0.2	65	161	0.2
Total	**32950**	**81421**	**100**	**32711**	**80830**	**100**

Adapted from JSA (1994). Total acres differ from deeded acres due to minor boundary inaccuracies in database. (Source: FHL, INRMP, 2004)

Figure 11. Fort Hunter Ligget Communities in Each Major Watershed

Reservoir Environment

Habitats in the vicinity of the reservoirs include annual grassland, blue oak woodland and chaparral. Open areas on the hillsides surrounding the Nacimiento and San Antonio Reservoirs are dominated by annual grassland used for livestock grazing. Grasslands adjacent to the Nacimiento spillway are disturbed (i.e., ruderal) from previous dam construction activity. A large percentage of the plant species that occur in this habitat are non-native.

Non-native grasses and other herbaceous annuals that are common in this habitat include wild oat (*Avena fatua*), soft chess (*Bromus hordeaceus*), foxtail chess (*Bromus madritensis*), black mustard (*Brassica nigra*), sky lupine (*Lupinus nanus*), and Italian ryegrass (*Lolium multiflorum*). Immediately below the spillway, coyote brush (*Baccharis pilularis*) and Fremont cottonwoods (*Populus fremontii*) are scattered along the banks of the Nacimiento River; however, no mature riparian habitat is present directly below the spillway.

The area provides habitat for many of the animals that are common in the grasslands of southern Monterey and northern San Luis Obispo County. Wildlife species observed in this habitat during field surveys conducted for the Salinas Valley Integrated Regional Water Management

Functionally Equivalent Plan Update (2006) include California ground squirrel (*Spermophilus beecheyi*), mourning dove (*Zenaida macroura*), lark sparrow (*Chondestes grammacus*), and savannah sparrow (*Passerculus sandwichensis*).

Blue oak woodland, dominated by open stands of mature blue oaks (*Quercus douglassii*) and foothill pines (*Pinus sabiana*) is the predominant plant community in the vicinity of the reservoirs. Shrubs scattered in the understory include poison oak (*Toxicodendron diversilobum*), toyon (*Heteromeles arbutifolia*), and California buckeye (*Aesculus californicus*). Blue oak woodland provides important habitat for many of the wildlife species that occur in the foothills surrounding the Salinas Valley. Common species observed during field surveys include western scrub-jay (*Aphelocoma californica*), western bluebird (*Sialia larkia*), and western fence lizard (*Sceloporus occidentalis*).

Dense patches of chaparral occur on some of the steeper south- or east-facing slopes in the area. Chaparral is usually dominated by chamise (*Adenostoma fasciculatum*).

Shoreline and open water habitat on Nacimiento Reservoir and San Antonio Reservoir provides suitable habitat for a number of terrestrial and semi-aquatic wildlife species such as great blue heron (*Ardea larkia*) ruddy duck (*Oxyura jamaicensis*), western grebe (*Aechmophorus occidentalis*), and Clark's grebe (*Aechmophorus larkia*) (Salinas Valley Integrated Regional Water Management Functionally Equivalent Plan Update, 2006).

Downstream of Reservoirs

Habitat in the lower Nacimiento River is controlled largely by water releases from the reservoir above. The lower Nacimiento River is characterized by a low gradient and long, wide sections with sparse riparian vegetation. Typical substrate consists of gravel with lesser amounts of sand and cobble. Water temperatures in the River are highly variable; depending on reservoir releases, air temperature and reservoir storage. Prior to construction of the San Antonio Dam, the San Antonio River normally did not reach the Salinas River in late summer (Monterey County Flood and Water Conservation District, 1989). Conditions in the lower San Antonio River are dependent on releases from San Antonio Dam. The lower San Antonio River was characterized as a small permanent stream with a large quantity of submerged aquatic vegetation and some emergent aquatic vegetation. The aquatic habitat consists primarily of shallow-run habitat, and lesser amounts of pool and riffle habitat. The channel substrate is primarily composed of equal parts of sand and gravel with lesser amounts of cobble and silt (SVWP EIR, April 2002).

Figure 12. River Downstream of Nacimiento Dam

In general, water released through the Nacimiento Reservoir outlet is at a relatively constant temperature of 52 to 54° F (11.1° Celsius I to 12.2 ° C). The water warms rapidly as it moves downstream, generally in relation to fluctuation in daily air temperature. At minimum release levels (25 to 30 cfs), water temperature can increase to as much as 73°F (22.8° C) within 5 miles of the dam, and 75°F (23.9° C) within 10 miles of the dam. During the summer conservation release period (with flows of 300 cfs or more), water temperature is generally maintained at less than 64°F (17.8° C) within 5 miles of the dam, and 68°F (20° C) or less within 10 miles of the dam (SVWP EIR, April 2002).

Steelhead Habitat

NMFS has noted the paucity of data on steelhead in the Salina River System in its 2007 Biological Opinion.

> *Givern that there are very few data available on steelhead in the Salinas River, NOAA's Natinal Marine Fisheries Service has utilitzed data from nearby watersheds which tend to be similar to the Salinas River. (*NMFS, SVWP Flow Proposal for the Biological Needs of Steelhead in the Salinas River, April 2005)

The following information is excerpted from the Salinas Valley Water Project Biological Opinion, 2007.

> *Much of the habitat in the lower Nacimiento River is potentially usable for steelhead. Several potential spawning areas have been documented in the lower river and there are many deep pools. At times, there may be unfavorably warm water temperatures in the lower Nacimiento River, but deep pools may provide thermal refuge for steelhead. One area of the river continues to contain aquatic habitat in relatively good condition for steelhead. Reconnaissance level habitat surveys conducted immediately downstream of the Dam in spring 2000 documented the presence of steelhead spawning and rearing habitat with good cover, relatively cool water temperatures and dense riparian vegetation, and less fine sediments than found downstream. Even with these relatively better habitat conditions, habitat value for steelhead in this area is heavily influenced by flow levels and quality of water released from the reservoir .*

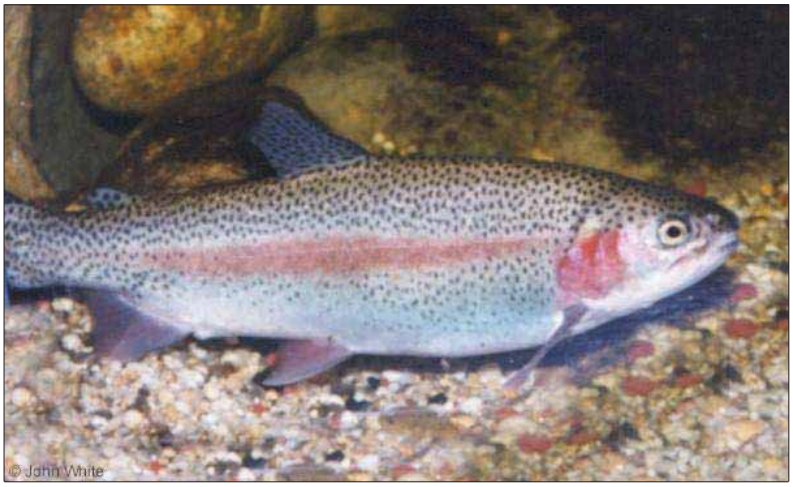


Figure 13. Steelhead Trout

> *Areas above the present sites of the Nacimiento and San Antonio dams comprised some of the best historical spawning and rearing habitats in the watershed. The Salinas Dam, which forms the Santa Margarita Reservoir in San Luis Obispo County, and the Nacimiento and San Antonio dams were constructed without fish passage*

facilities, and, therefore, the historic habitats above these dams are no longer available to steelhead. As a result, 286 miles of spawning and rearing habitat for steelhead have been lost; an estimated 149 miles of spawning and rearing habitat remain in the watershed (NMFS 2005c). Critical habitat for steelhead in the watersheds has been designated below both of the dams to the confluence to the Salinas River.

The current steelhead population in the Nacimiento River is likely at very low abundance. A redd survey conducted on February 26, 2003, between river mile 0 and approximately river mile 7 resulted in zero redds observed. The three miles of river closest to the dam were not surveyed. This un-surveyed area is thought to have the best spawning and rearing habitat based on sightings in 1998 and an unconfirmed sighting in 2001, steelhead are believed present within the Nacimiento River during years with high winter flow events in the Salinas River.

Steelhead Spawning and Rearing Habitat

The San Antonio River was one of the three most important spawning and rearing tributaries for Salinas River steelhead. The confluence of the Salinas and San Antonio Rivers is approximately 107 miles upstream from the mouth of the Salinas River. Following construction of the San Antonio Dam, the pattern of flow releases from the dam was not predicted to provide perennial flow conditions in the lowermost San Antonio River, and CDFG decided against developing a fishery downstream from the dam. Although the availability of steelhead spawning and rearing habitat was limited in the lower San Antonio River even before dam construction, CDFG still identified steelhead as inhabitants of the San Antonio River below the reservoir as of 1981. Presumably, it was assumed that steelhead still entered the lower river from the Salinas River when runoff was sufficient to provide a continuous migration corridor. However, lack of access to historic spawning and rearing habitats in the perennial headwaters greatly limits steelhead use of the San Antonio River. Currently, hydrologic conditions downstream of San Antonio Dam and other habitat conditions do not favor steelhead. NMFS staff walked the lower San Antonio River in August 2004, and noted riparian vegetation, gravels, and shading that could likely provide suitable spawning and rearing habitat. Nonetheless, surveys of the lower San Antonio River completed after the placement of San Antonio Dam show steelhead use is low.

Oak Shores Area

Two sensitive habitats were identified during a California Natural Diversity Database (CNDDB) search as occurring within the search area: sycamore alluvial woodland and valley oak woodland. Valley oak woodland occurs within the study area. The CDFG considers valley oak woodland to be a sensitive habitat (CNDDB, 2007) and of high inventory priority (CDFG, 2003) (Oaks Shores EIR, 2007).

Camp Roberts

At Camp Roberts, the Grassland Ecosystem, which includes the nutrients, soils, vegetation, plants and animals, and all the processes that have an influence on them, such as erosion, grazing, drought, flood, predation, as well as effects from humans covers roughly 20,634 acres (48 percent) of the training site. The Oak Woodland Ecosystem covers roughly 17,622 acres (41 percent) of the training site. The Riparian Ecosystem covers roughly 2,266 acres (5 percent) of the training site. The Chaparral/Scrub Ecosystem covers roughly 539 acres (1 percent) of the training site (Camp Roberts Integrated Natural Resource Management Plan, 2000). Natural Vegetation Communities and Ecosystems on Camp Roberts are provided in Figure 13.

Ecosystem/ Community or Habitat	Vegetation*	Wildlife*
Ecosystem		
Mixed Chaparral	Bigberry manzanita, buck brush, toyon, chamise, California sagebrush, black sage, hollyleaf cherry, poison oak, bedstraw, California peony, fiesta flower, deer weed, and grasses	Orange-crowned warbler, wrentit, California thrasher, brush rabbit, California mouse, western fence lizard, southern alligator lizard, western spotted skunk, and gray fox
Coastal scrub	Sticky monkeyflower, California sagebrush, black sage, California buck-wheat, and various grasses and forbs	Similar to those listed for grassland and chaparral
Closed-cone pine/cypress	Shrubby understory, □anzanita, poison oak, and some forbs	Similar to those listed for coastal scrub
Grassland Ecosystem		
Annual Grassland	Slender wild oats, brome grasses, pacific fescue, purple needlegrass, clover species, lupine species, goldfields, fiddleneck, popcorn flower, blue dicks, common plantain, filaree, tocalote, soft chess, and tarweed	California vole, California ground squirrel, western meadowlark, California horned lark, savannah sparrow, western kingbird, coyote, American badger, San Joaquin kit fox, and red-tailed hawk
Blue oak savanna	Blue oak, soft brome, ripgut brome, holly-leaf redberry, toyon, valley oak	Wild turkey, mule deer, acorn woodpecker, band-tailed pigeon, western bluebird, American kestrel, bushtit, gray fox, and bobcat
Oak Woodland Ecosystem		
Blue Oak woodland	Blue oak, coast live oak, annual grassland species	Wild turkey, mule deer, acorn woodpecker, band-tailed pigeon, western bluebird, American kestrel, bushtit, gray fox, and bobcat, dusky footed woodrat, California ground squirrel
Valley Oak Woodland	Valley oak, poison oak, toyon, coffeeberry, grasses, and forbs	
Coastal Oak woodland	Coast live oak, poison oak, crimson sage, miner's lettuce, California buttercup, and annual grasses	
Riparian Woodland Ecosystem		
Mixed riparian woodland	Fremont cottonwood, western sycamore, valley oak, box elder, elderberry, willow, mule fat, coyote brush, and mugwort	Wood duck, wild turkey, California quail, red-shouldered hawk, Nuttall's and downy woodpeckers, Bewick's wren, rufous-sided towhee, raccoon, Virginia opossum, long-tailed weasel, Pacific chorus frog, southwestern pond turtle, bald and golden eagles, and tule elk
Riparian scrub	Sandbar willow, coyote brush, and mule fat	
Valley foothill riparian[1] (includes sycamore alluvial woodland)	Valley oak, poison oak, toyon, coffeeberry, grasses, and forbs, sycamore	

Figure 14. Natural Vegetation Communities and Ecosystems on Camp Roberts

Ecosystem/ Community or Habitat	Vegetation*	Wildlife*
Wetland/Aquatic Ecosystem		
Seasonal wetlands (including vernal pools and artificial seasonal wetlands)[2]	Water pygmy-stonecrop, Vasey's coyote thistle, Mediterranean barley, small stipitate popcorn flower, popcorn flower, annual hairgrass, woolly marbles, crassula, spikerush, water starwort, filaree, vinegar weed, tarweed, Mediterranean barley, rabbitsfoot grass, curly dock, and toad rush	Vernal pool fairy shrimp, western spadefoot toad, western toad, Pacific chorus frog, mallard, cinnamon teal, killdeer, great blue heron, black phoebe, barn swallow, bullfrog, gopher snake, common garter snake, striped skunk, raccoon, and bats
Clay flats[2]	Annual hairgrass, Mediterranean barley, popcornflower, adobe navarretia, dwarf flax, and turkey mullein	Similar to that described for annual grassland habitat
Perennial Streams[2]	Generally unvegetated, but some support blue wildrye, Mediterranean barley, spreading rush, rabbitsfoot grass, curly dock, and popcorn flower	Similar to those described for annual grassland habitat
Intermittent Stream Drainages[2]	Slender wild oats, brome grasses, pacific fescue, purple needlegrass, clover species, lupine species, goldfields, fiddleneck, popcorn flower, blue dicks, common plantain, filaree, tocalote, soft chess, and tarweed	Same as annual grasslands.
Rivers[2]	None.	Pacific lamprey, Sacramento sucker, hitch, Sacramento squawfish, speckled dace, unarmored threespine stickleback, coastal rainbow trout, and prickly sculpin
Ponds and Reservoirs[2]	Cattails, bulrush, rush, willow, smartweed, lesser duckweed, streamside monkeyflower, white sweetclover, rabbitsfoot grass, and curly dock	Mallard, ring-necked duck, ruddy duck, cinnamon teal, and other waterfowl, great blue heron, great egret, greater yellowlegs, killdeer, red-winged blackbird, raccoon, coyote, gray fox
Freshwater marsh[2] (includes springs)	Cattails, bulrush species, rush species, willow species, smartweed, lesser duckweed, streamside monkeyflower, white sweetclover, rabbitsfoot grass, curly dock	Mallard, ring-necked duck, ruddy duck, cinnamon teal, and other waterfowl, great blue heron, great egret, greater yellowlegs, and killdeer.

*Scientific names are cataloged in Appendix B and C
[1]Sensitive natural communities (NDDB, 1999)
[2]A habitat type; not a natural community type.

Figure 14 (continued). Natural Vegetation Communities and Ecosystems on Camp Roberts

Water habitats

Three rivers, the Nacimiento, the Salinas, and the San Antonio traverse Camp Roberts covering a total of about 264 acres. The species listed in Figure 14 are those commonly associated with the rivers on Camp Roberts; however, the rivers also supply a drinking water source for many other animals on the training site.

Camp Roberts has 13 ponds and reservoirs (65 acres), which are either natural or artificially-created for use as livestock ponds and for flood control. These areas are now fenced to exclude livestock. Some medium and larger ponds support emergent wetland vegetation and riparian species along the receding water line or low water edge. These areas typically are inundated for a long duration and are considered jurisdictional wetland by the U. S. Army Corps of Engineers. Unvegetated portions of ponds are typically considered other waters of the United States because they lack hydrophytic vegetation. The low water zone, which is also dominated by hydrophytic species, would be considered jurisdictional wetland; however, unvegetated and vegetated components were not delineated separately in a Jones and Stokes Associates 1996 survey (CR INRMP, 2000).

A total of 120 aquatic species representing 64 families of organisms were recorded from rivers, ponds, and reservoirs on Camp Roberts. Three stations on the Nacimiento River (Twin Bridges, High Water Bridge, and Low Water Bridge) had the highest diversity of aquatic organisms. The greatest diversity of aquatic insects (28 species, representing 21 families) was recorded at a relatively undisturbed site on the Salinas River in the northeast region of the camp. Two families of mayflies (Ephemerellidae and Siphlonuridae), one family of aquatic bugs (Naucoridae, creeping water bugs), and one family of stoneflies (Isoperlidae) were uniquely surveyed at this downstream Salinas River station on Camp Roberts. An additional sensitive wildlife species occurring in the Nacimiento River is the southwestern pond turtle (CR INRMP, 2000).

Eight species of fish, comprising approximately 44 percent of the species native to the Salinas River drainage have been recorded at Camp Roberts from the Nacimiento River: Pacific lamprey, Sacramento sucker, hitch, Sacramento squawfish, speckled dace, unarmored three-spine stickleback, coastal rainbow trout, and prickly sculpin (CR INRMP, 2000).

Introduced species (either to North America and/or California) found were: goldfish, common carp, western mosquito fish, green sunfish, bluegill, largemouth bass, black crappie, and black bullhead. White bass and catfish have also been caught during the sport fishing program in the Nacimiento River (CAEV-CR database). Only one of the 10 ponds surveyed (Pond #8—Twin Ponds West) was inhabited by fish (introduced bluegill and black bullheads).

Plants of Camp Roberts

The Oklahoma Biological Survey (1997) undertook a post-wide floristic inventory in 1993 and 1994. Several specimens of each plant were collected, vouchered in a local herbarium, and laminated for a reference collection at Camp Roberts. Since that time, Land Condition Trend Analysis crews have collected and vouchered undocumented plants for inclusion in the reference collection each year during annual surveys.

As of September 2000, more than 613 plant species have been identified at Camp Roberts. The CR INRMP included the following on introduced species of plants.

> *Using the known species in 1998, Bern (1999) calculated that approximately 23 percent of known plant species at Camp Roberts (378 species) were introduced (i.e., non-native, exotic, or alien). Most of the introduced species were grasses (96 percent) (Bern, 1999). All floristic data collected in these surveys are included in the Camp Roberts Environmental Office database and are currently being update* (CR INRMP, 2000).

C. Water Quality

The existing water quality conditions of the Nacitone watersheds are summarized here by inspection of documents that describe past water quality assessment as well as the Nacitone Watershed Resources Inventory Final Technical Memorandum—Water Resources, Water Quality and Sediment Supply. No new data was generated for this study. State designated beneficial uses and point and nonpoint sources of pollution are also addressed in this section as established by Cal EPA and SWRCB regulatory authority.

General Regulatory Setting for Water Quality

The 1970 Porter-Cologne Water Quality Control Act gives the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCB) authority to perform water quality regulatory oversight regardless of the source. Water quality control is defined by the Act as "the regulation of any activity or factor which may affect the quality of the waters of the state and includes prevention and correction of water quality or nuisance." Federal Clean Water Act Section 208 funds have been used to assess water quality conditions in California's 16 hydrologic basins and create water quality management plans, familiarly known as "Basin Plans" (Range Water Quality Management Plan, 1995).

The water quality objectives listed in the Basin Plan for the Central Coast region are intended to protect the beneficial uses of the reservoir, which include the following elements:

- Municipal and domestic water supply,
- Agricultural water supply,
- Groundwater recharge,
- Water contact recreation,
- Non-contact water recreation,
- Wildlife habitat,
- Cold fresh water habitat,
- Warm fresh water habitat,
- Fish spawning,
- Rare, threatened, or endangered species,
- Freshwater replenishment,
- Navigation, and
- Commercial and sport fishing

Waterbody Name	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	RARE	FRESH	NAV	POW	COMM	BIOL	EST	AQUA	SAL	SHELL
San Antonio R. downstream from Res.	X	X		X	X	X	X	X		X	X	X	X				X					
San Antonio Reservoir	X	X			X	X	X	X	X	X		X	X	X	X	X	X					
San Antonio R. upstream from Res.	X	X		X	X	X	X	X	X	X	X	X	X	X			X					
Salinas R. Nacimiento R.- S. Margarita Res.	X	X	X		X	X	X	X	X	X	X	X	X				X					
Nacimiento R. upstream of Res.	X	X			X	X	X	X	X	X		X	X	X			X					
Salmon Creek	X					X	X	X	X		X	X	X				X					
Nacimiento Reservoir	X	X			X	X	X	X	X	X		X	X	X	X		X					
Nacimiento R. downstream of Res.	X	X		X	X	X	X	X	X	X	X	X	X				X					
Las Tablas Creek	X	X			X	X	X	X	X	X		X	X				X					
Las Tablas Creek, north fork	X	X			X	X	X	X	X			X	X				X					
Las Tablas Creek, south fork	X	X			X	X	X	X	X			X	X				X					
Franklin Creek	X	X			X	X	X	X									X					

The following is a list of codes associated with beneficial uses:
MUN = municipal and domestic supply,
AGR = agricultural supply,
PROC = industrial process supply,
IND = industrial service supply,
GWR = groundwater recharge,
REC1 = water contact recreation,
REC2 = non-contact recreation,
WILD = wildlife habitat,
COLD = cold fresh water habitat,
WARM = warm fresh water habitat,
MIGR = migration of aquatic organisms,
SPWN = spawning, reproduction and/or early development,
RARE = rare threatened or endangered species,
FRESH = freshwater replenishment,
NAV = navigation,
POW = hydropower generation,
COMM = commercial and sport fishing

Figure 17. Identified Uses of Inland Surface Waters per the Central Coast RWCQB Basin Plan

Further, under Section 303(d) of the 1972 Federal Clean Water Act, states are required to develop a list of water quality-limited stream segments that do not meet water quality standards, commonly referred to as the 303d list. The law requires that the states establish priority rankings for water on the lists and develop action plans, called Total Maximum Daily Loads (TMDL), to improve water quality. The RWQCBs are primarily responsible for developing the list, which is approved by both the SWRCB and the U.S. Environmental Protection Agency (Central Coast Water Quality Data Synthesis, Assessment, and Management [SAM] Project, Central Coast Water Quality Data Assessment Report, 2008.)

Total Maximum Daily Loads (TMDLs) in the Watersheds

Las Tablas Creek and Nacimiento Reservoir are listed as impaired for Metals on the 2006 Clean Water Act 303(d) list. In a RWQCB 1996 Water Quality Assessment Report, the RWQCB reports the Nacimiento Reservoir as impaired for metals (mercury) in fish tissue, and mainstem Las Tablas Creek and the north and south forks impaired for metals (mercury) associated with sedimentation as well as being high in total dissolved solids, electrical conductivity, sulfate, and nickel. The RWQCB's 2002 Watershed Management Initiative Report also indicates, "It is likely that nitrates in groundwater will increase in the future unless preventive measures are taken" (RWQCB WMI, 2002). As a result of the Clean Water Act 303(d) listing for Metals, the RWQCB adopted a TMDL for Las Tablas Creek and Nacimiento Reservoir in 2003; however, it was not approved by the SWRCB and is pending the results of the Record of Decision for the Klau Buena Vista Superfund Site.

Mercury TMDL and EPA Superfund Status

In many parts of the Nacimiento River watershed, the natural mercury levels in soil tend to be relatively high, since the area has numerous naturally occurring cinnabar (mercuric sulfide) deposits and mine sites. Estimates from the Regional Board Lake Nacimiento Loading Model indicate that approximately 77 to 93 percent of the total mercury loading into the reservoir enters from the Las Tablas Creek drainage area. (Las Tablas Creek and Lake Nacimiento, TMDL, 2002).

The Buena Vista and Klau mines in the Nacimiento River watershed have been identified as the primary point and nonpoint sources of mercury contamination in the watershed. Studies leading up to the total maximum daily load (TMDL) described the movement of mercury from the mines to Nacimiento Reservoir.

> *Below Buena Vista and Klau mines, mercury contaminated materials are primarily found in Las Tablas Creek sediments. It is presumed that coarser materials containing mercury are to be found throughout the sediment between the mines and Lake Nacimiento, and thus will continue to flow to the lake even if the mine facilities and surrounding hills cease to be a source of mercury pollution. Annual mercury loadings will depend on the proportion of this sediment stockpile that reaches the lake in any given year. It is possible that a high-level flood event (100-year storm or larger) could scour a very significant portion of this sediment from the Las Tablas Creek floodplain, although much sediment would be re-deposited in the floodplain channel as waters recede. Fine sediments would move more efficiently, so a very large percentage of the mercury-contaminated fines (silts and clays) will likely reach Lake Nacimiento. The level of Lake Nacimiento is seldom allowed to reach maximum stage, causing Harcourt Reservoir, a small impoundment located on Las Tablas Creek, adjacent to the reservoir and Nacimiento Reservoir waters to merge.*

Sediment-rich waters from Las Tablas Creek will deposit their fine suspended sediment load in the still waters of the lake. When the lake is at a low level, but receives high level floodwaters via the Las Tablas Creek Arm, previously exposed old lake floor sediments will be re-transported further north into the Las Tablas Arm and eventually into the main lake channel (Clean Lakes Assistance Program, 1994).

The TMDL identified control measures that were to be implemented at Buena Vista and Klau mines. Since the TMDL, the Buena Vista and Klau mines have been listed on the National Priority List (also known as the Superfund site list), which supersedes the TMDL. Remediation of the sites is under authority of the Environmental Protection Agency. A May 2007 EPA Newsletter for Klau and Buena Vista mines indicated that in June of 2006, EPA initiated a removal action. In 2007, the EPA installed several monitoring probes in streams to measure the effects of acid mine drainage on pH levels. An assessment will begin in spring 2008 to identify any endangered, threatened or sensitive plants or animals that may be affected by site contamination. EPA anticipates that a sampling plan for collecting soil samples and surface water samples will be completed by summer 2008.

Point Sources

The following are point sources, Leaking Underground Tank Clean up Sites, and permitted dischargers in the Watersheds.

Discharge	Point Source	Reference
Mercury	Buena Vista and. Klau Mines	Las Tablas Creek and Lake Nacimiento TMDL 2003
Potential Contaminants of Concern	**Leaking Underground Tank Clean Up Site (LUST)**	
Gasoline	Lake Nacimiento Resort boat launch	Geotracker RWQCB Case 3652
Gasoline	Lake San Antonio Resort Store and Fuel Station	Geotracker RWQCB Case 2905
	Dischargers with NPDES Permits	Reference permit #
	San Antonio River Watershed	
Sanitary wastewater	San Antonio Recreation Area South Shore Wastewater Facilities	RWQCB Order No. 01-131
Solid waste	Lake San Antonio North Shore Closed Class III Landfill	RWQCB Order No. R-32002-0056
Winery process wastewater	Winery	Waiver granted by RWQCB 9/17/03
Sanitary wastewater	San Antonio Recreation Area North Shore WWTP	RWQCB Order No. R3-2004-54
	Nacimiento River Watershed	
Solid Waste	Fort Hunter Liggett Class III Landfill Waste Disposal Site	RWQCB Order No. 87-149
	North shore Ski and Boat Club	RWQCB Order No. 89-74
Domestic wastewater	Heritage Ranch CSD WWTP	RWQCB Order No. R3-2006-0012
Domestic sanitary wastewater	Oak Shores Development Wastewater Treatment Plant – San Luis Obispo County Service Area No. 7	RWQCB Order No. 01-130
Domestic wastewater	Lake Nacimiento Resort	RWQCB Order No. 96-26

Figure 15. Point source Clean up Orders and Permitted Dischargers in the Watersheds

Heritage Ranch Community Service District (NRCSD) Discharge Permits

The CSD holds a Waste Discharge permit and an NPDES (National Pollution Discharge Elimination System) permit from the California Regional Water Quality Control Board, Central Coast Region for discharge of treated effluent. According to Heritage Ranch CSD Nacimiento Watershed Sanitary Survey (2005) the waste discharge permit is for discharge of Heritage Ranch treated effluent. The discharge point is an unnamed ephemeral creek. The discharge location is is on the district's 220 acre along G-14 (also known as Lake Nacimiento Drive), about 1.5 miles south of the entrance to Heritage Ranch and approximately 4 miles from the confluence with the Nacimiento River. Treated effluent entering the unnamed tributary flows approximately one mile downstream then percolates into the soil. The NPDES is required because during very heavy rain periods, discharge to the ephemeral creek could reach the Nacimiento River. The basic effluent limitations set by the RWQCB are that the discharge must be treated to a degree that protects groundwater, streams and riparian habitat. The current five-year permit held by Heritage Ranch Community Service District expires in 2011. Daily, monthly and annual testing is required of wastewater effluent. The State Water Resources Control Board must license district employees operating the wastewater treatment plant as Wastewater Treatment Plant Operators. The District has four employees currently certified as Operators (Heritage Ranch Sanitary Survey, 2005).

The quality of the Heritage Ranch Community Service District's wastewater influent is very good. This is characteristic of an influent that comes from almost all residential homes. There are few businesses in Heritage Ranch. The effluent is also correspondingly of high quality. The District has a history of compliance with all RWQCB limitation requirements. Summarized below are key effluent monthly limitations in the Discharge Order.

Parameter	Units	Limitation	Average
BOD	mg/L	30	20.09
TSS	mg/L	30	21.18
Settleable Solids [a]	ml/L	.1	0.01
Oil and Grease	mg/L	10	2.3
pH	--	6.5 – 8.3	7.15
Nitrate [a]	mg/L (as N)	8.0	non detect
Chlorine	mg/L	non detect	non detect
Copper [b]	µg/L	25.0	9.2
Mercury [b]	µg/L	0.07	.006

[a] Settleable solids and nitrates are daily maximum limitations.
[b] Copper and mercury limitations are interim until 4/1/10.
Reported data includes 2006 results.

Figure 16. Key effluent monthly limitation for the Heritage Ranch Wastewater Discharge

Nonpoint Sources

San Antonio River watershed

Analysis of the WRI documents did not reveal specific information on nonpoint sources within the San Antonio River watershed.

Nacimiento River watershed

The Heritage Ranch CSD's Nacimiento Watershed Sanitary Survey (2005) identified two primary potential nonpoint sources of contamination: (1) people who recreate on and around Nacimiento Reservoir and (2) cattle that have unrestricted access to almost the entire shoreline. Both of these conditions have existed either before or since the reservoir was created over 50 years ago.

A secondary source of potential contamination was identified in the form of wild-land fires, with the resulting erosion and debris affecting the reservoir. The resulting water runoff and sedimentation caused by fire burning of natural vegetation causes the contamination. The California Department of Forestry is responsible for fire suppression within the watershed. An accidental fire or a controlled burn that becomes out of control is of concern in this area (HR Sanitary Survey, 2005).

Mercury, while it has a definable point source, also behaves as a nonpoint source as it is carried from the point source, the mines, in sediment as it runs off in rain events. It has thus contaminated the food chain of Nacimiento Reservoir. Fish throughout Nacimiento Reservoir, including the Narrows, were found to have high levels of mercury. Mercury is a metal that can be harmful to the human nervous system when it is present in a form called "methylmercury." Methylmercury can affect human development. When mercury is in the sediment of a reservoir, small organisms transform it into methylmercury in their bodies. When small fish eat these small organisms they consume the methylmercury in the organisms. Predatory fish such as white and spotted bass that eat smaller fish consume all the methylmercury in their prey; therefore predatory fish have the highest levels of methylmercury (Oak Shores EIR, 2007). This has led to a San Luis Obispo County Environmental Health Division fish advisory for Nacimiento Reservoir that advised limited consumption of bass from the reservoir.

According to the Heritage Ranch CSD Sanitary Survey, studies and samples of reservoir sediment deposits revealed that mercury contamination exists in the water and bottom sediments of the reservoir and were highest in the Las Tables Creek arm of the reservoir. The water samples contained lower mercury concentrations than the bottom sediment samples. Of the 10 surface samples and 13 bottom samples measured, all were below the MCL (maximum contaminant level) for mercury of 2 micrograms/liter. The County of San Luis Obispo has sampled near the dam for mercury concentration. There have been 60 samples taken near the dam and all results have been <1 μg/L. The HRCSD sampling at its water intake facility at the Nacimiento River has also not detected mercury concentrations.

According to the Heritage Ranch CSD Sanitary Survey (2005) samples taken in 1995 in the following locations contained both *Giardia* and *Cryptosporidium*: at the dam, near a cattle grazing area, in the Nacimiento River upstream of the Heritage Ranch CSD well and downstream of the Heritage Ranch CSD final effluent entry site. Cattle were present only near the cattle grazing area. Both Giardia and Cryptosporidium were present at all of these locations and are generally expected in any surface water. However, it should be noted that reservoir water samples collected near the dam in 2002 by San Luis Obispo County Water Quality Lab did not contain *Giardia* or *Cryptosporidium* cysts (HR Sanitary Survey, 2005).

Humans carry both of these microorganisms and can contribute to their presence in water. *Giardia* and *Cryptosporidium* concentrations have the potential to be greatly increased by certain activities in a watershed. Fecal contamination from mammals greatly increases *Giardia* and *Cryptosporidium* loading to a water body compared to background levels as well as coliforms, *E. coli*, and other contaminants. Livestock in particular are significant sources of these microorganisms, especially *Cryptosporidium*. Beavers are especially known to carry *Giardia*.

Consumption of water with these microorganisms present can cause severe, long lasting (sometimes for a lifetime) gastrointestinal illness, sometimes with lethal consequences. It is important to note that consumption can be intentional (water users) or unintentional (swimming, water skiing) (summarized by L. Wallender, personal communication 2007).

While a comprehensive sediment budget was not found in documentation for the WRI, sediment yield in the watersheds was studied relative to mercury in the Las Tablas tributary to the Nacimiento Reservoir by the Coastal Resources Institute for the RWQCB and published in the Clean Lakes Assistance Program for Lake Nacimiento (1994). The value of 1,000 tons/square mile/year (about 1.56 tons/acre) was chosen as a relatively conservative sediment yield value for the entire Nacimiento River watershed basin. The figure was applied to the entire watershed, for although slope steepness was greater on the west side of the river, rocks are generally softer and more erodable on the east side of the river. With a watershed area of about 82 square miles (about 52,480 acres), sediment yield data from nearby watersheds would suggest a typical year's production of about 1,000 tons/square mile (Clean Lake Assistance, 1994). Sediment yield information is relevant in determining a rate at which mercury could be entering into Nacimiento Reservoir from Las Tablas Creek specifically and from the larger watershed generally. Sedimentation rate information would also provide an understanding of the expected life-spans of the reservoirs. SH+G has conducted a preliminary sediment budget for both watersheds which is discussed below in the Reservoir Features and Management section of Part 2.

Illegal drug production is also a threat to watershed health. As described by journalist Kera Abraham:

> *On the Los Padres site alone I discover three different brands of fertilizer, a hand-pump pesticide product and gopher killer pellets made with highly toxic zinc phosphide. Once introduced to the environment, these kinds of pesticides can ripple up the food chain, poisoning cougars, coyotes and condors that eat the tainted varmint. Totally unregulated in the hands of illegal growers, ag chemicals can do serious damage to the air, soil, water and wildlife.* (Wasted Wilderness from Monterey County Weekly, 2007).

The article also reported trash heaps associated with areas that had been used to grow marijuana. The Ventana Wilderness Alliance in coordination with the Forest Service is pursuing clean-up efforts.

San Antonio Reservoir Water Quality

Temperature and Dissolved Oxygen

Thermal stratification may occur in San Antonio Reservoir during spring, summer and fall. During the stratification period, surface water temperatures may range between 68 degrees F and 81 degrees F, while at depths greater than about nine meters water temperature is typically between 55 and 63 degrees F. Temperature profiles show a pronounced thermocline between approximately 13-30 feet in depth. These temperatures would be suitable for trout and other cold-water species, except trout also need relatively high dissolved oxygen (DO) concentrations. During summer months, the DO falls to very low levels below the thermocline, negating the possibility of trout habitat (SVWP EIR, April 2002).

Constituents

The Monterey County Parks Department utilizes San Antonio Reservoir water for public use. One measure of overall water quality that has been collected (October 13, 1997, MCWRA) is electrical conductivity (EC). The measured levels of EC of San Antonio Reservoir water ranged from 100 to 400 µmhos/cm, with an average value of approximately 300 µmhos. According to the SVWP EIR, this translates into an approximate total dissolved solids (TDS) level of 210 mg/l. The TDS secondary drinking water quality standard upper limit is 1,000 mg/l. Manganese levels, reported at 210 to 470 micrograms/liter, exceeded the Secondary Drinking Water Standard, as established by U.S. EPA, which is 50 micrograms/liter. The highest nitrate reported by the MCWRA is 4 mg/L as NO3, which is below the drinking water MCL of 45 mg/L as NO3 (SVWP EIR, April 2002).

Nacimiento Reservoir Water Quality

The Nacitone Steering Committee elected to contract with Swanson Hydrology and Geomorphology to review information compiled in the WRI Analysis and water quality data collected by the San Luis Obispo County Public Works Water Quality Lab between October 1995 and 2007 at the log boom in Nacimiento Reservoir. The remainder of the Nacimiento Reservoir Water Quality section is excerpted from a technical memorandum produced by SH+G.

> *Analysis of the Water Quality Lab data is useful as a cursory screening of water quality trends in the reservoir and watershed. Because these data were only collected at the log boom, their applications to understanding water quality issues that affect human health are limited. A much more comprehensive and long-term sampling effort within the reservoir, especially within the various arms and inlets of the reservoir where recreational use is high, would be necessary to develop a more complete picture of water quality and its potential impact to beneficial uses and human health.*
>
> *In the summer months, Lake Nacimiento is thermally stratified. Thermal stratification results in two distinct zones within the reservoir that have implications on water quality, reservoir circulation, and biological productivity. The upper layer, referred to as the epilimnion is well mixed and interacts with the surface water. The lower layer, referred to as the hypolimnion tends to be cooler, is not well mixed, and tends to have lower dissolved oxygen due to lack of replenishment from the upper layer. The thermocline, a transitional layer between the epilimnion and hypolimnion, varies seasonally and with changes in wind and temperature patterns, but typically occurs at depths ranging from 20- 30 feet. Samples were collected by SLO County in both the epilimnion and hypolimnion of the reservoir. The SLO County data includes sampling and analysis for the following constituents:*
>
> - *Physical parameters including temperature, pH dissolved oxygen (DO) and turbidity;*
> - *Inorganics including various metals;*
> - *General mineral content including chloride, sulfate and sodium.*
> - *Nutrients including various forms of nitrogen and phosphorus*
> - *Organics including volatile organic compounds (VOCs), synthetic organic chemicals (SOCs) and Methyl tert-butyl ether (MTBE); and*
> - *Micro-organisms including total coliform and E. coli*

Selected constituents in the SLO County data, collected at the "log boom", were evaluated for trends throughout the period of record and individual measurements that exceed the water quality objectives listed in the Basin Plan for the Central Coast region (RWQCB, 1999). In general, the analysis of the existing water quality data focuses on the key beneficial uses that are of concern to the NWSC, although discussion is provide for other beneficial uses if the observed impact on water quality in notable. A general discussion of water quality as it relates to water supply is also provided.

Physical Parameters

Physical water quality parameters influence numerous beneficial uses including, but not limited to, wildlife habitat, cold and warm fresh water habitat, and fish spawning. Figure 18 shows the trend in physical water quality parameters for the period of record. Seasonal temperature fluctuations in the epilimnion are significant, varying approximately 15ºC annually; temperature flux in the in hypolimnion is less pronounced, though the data show it can be significant. The Regional Water Quality Control Board (RWQCB) has not established a temperature threshold for the "cold fresh water habitat" beneficial use, but 20ºC is often considered the maximum limit for salmon and trout habitat. Epilimnion temperatures in the late summer and early fall exceed this threshold, but the hypolimnion generally remains below 20ºC. In the hypolimnion, dissolved oxygen (DO) concentrations are a limiting factor for salmon and trout habitat; the stated water quality objective is e"7.0 mg/L, which is often not met (Figure 18). Dissolved oxygen is a measure of the amount of oxygen dissolved in water. This oxygen is absorbed by fish and other aquatic species through their gills.

The data show turbidity in the reservoir often spikes with the influx of sediment during large winter storms (Figure 18). The sediment settles out in the summer and turbidity is not thought to be a limiting factor for aquatic wildlife-related beneficial uses. Water pH was generally recorded in the range of the water quality objectives.

Inorganics

Inorganic constituents, which include heavy metals, can be toxic to aquatic organisms and wildlife. High concentrations of metals can degrade or limit wildlife-oriented and domestic beneficial uses. Heavy metals are of particular concern for wildlife species that are consumed by humans because they accumulate in the tissue of organisms higher in the food chain. Figure 19 shows the trend for selected inorganic water quality parameters for the period of record. There are no major exceedances of the established water quality objectives, nor are there any obvious trends that would suggest beneficial uses will be adversely impacted by inorganic constituents.

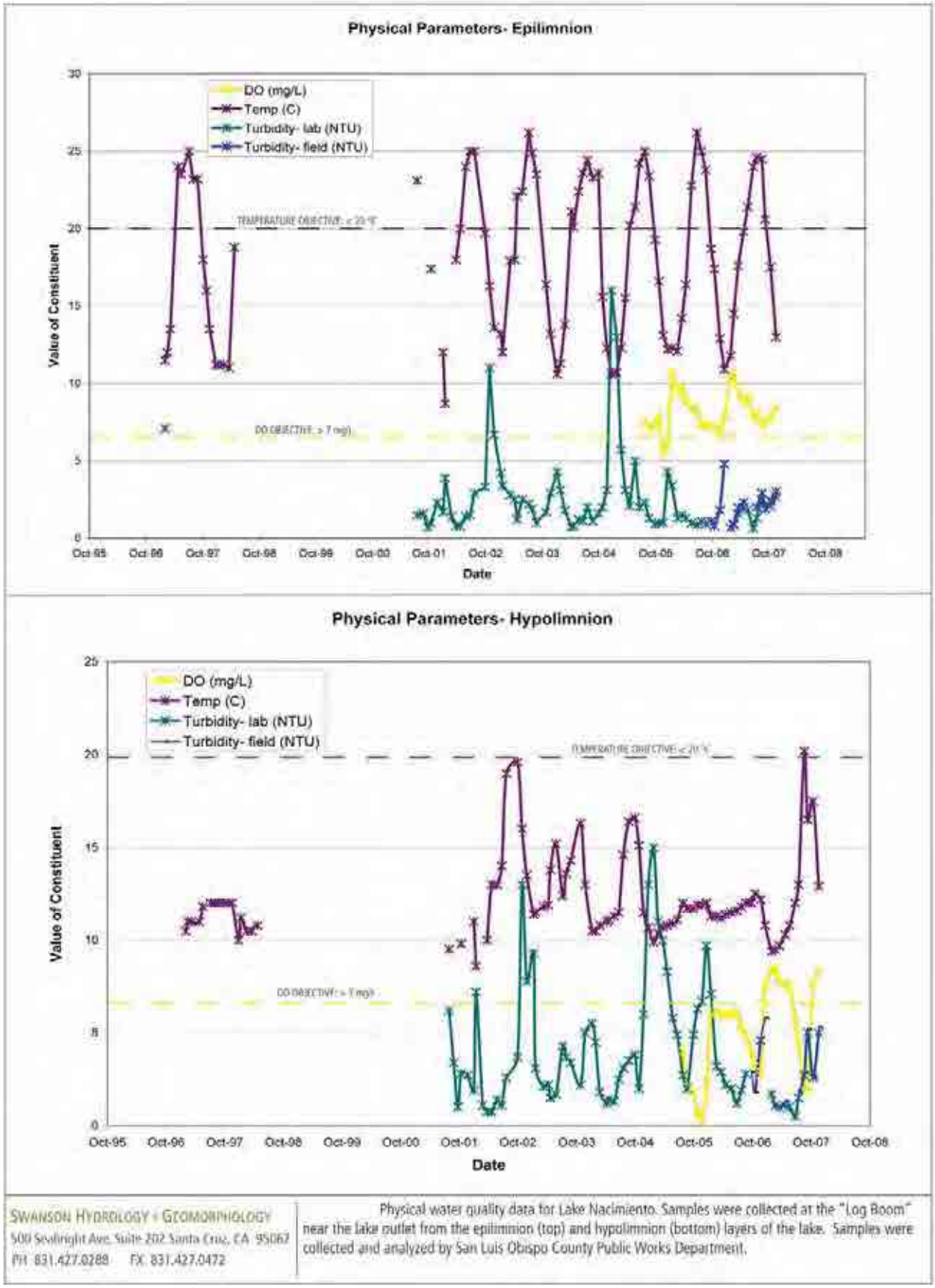


Figure 18. Physical Water Quality of Lake Nacimiento

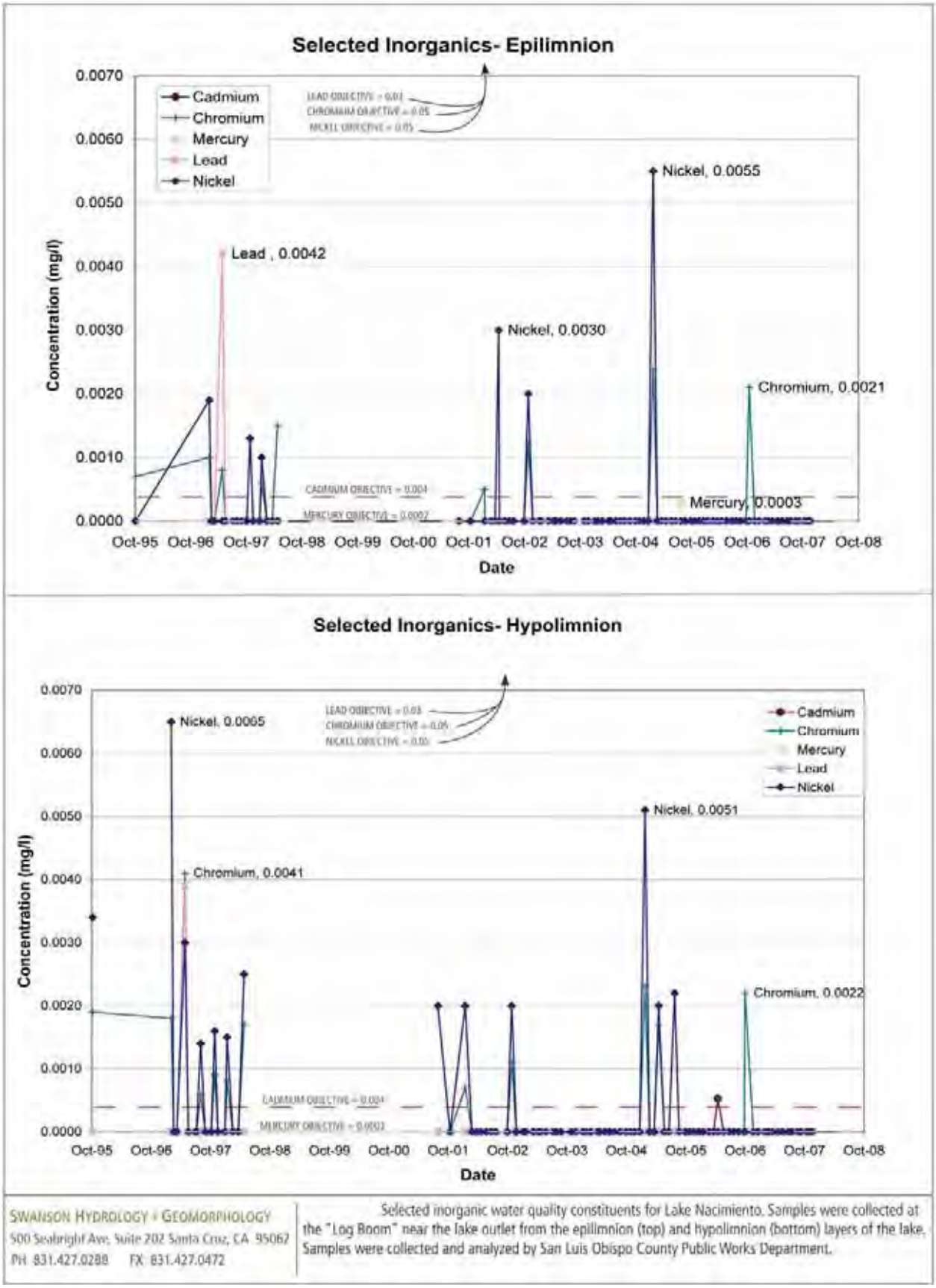


Figure 19. Selected Inorganic Water Quality Constituents from Lake Nacimiento

Mercury is a known contaminant of concern in the watershed. A sample collected from the epilimnion in August 2005 show mercury concentrations that exceed the established water quality objectives by 0.0001 mg/l (the water quality sample that recorded mercury levels above the detection limit represents 1 out of 118 samples collected at the log boom). Although mercury is toxic at low concentrations, this level of exceedance probably does not constitute a water quality concern. A more thorough analysis of mercury is being conducted by the Environmental Protection Agency (EPA) due to the presence of abandoned mercury mines in the Las Tablas watershed, a tributary of the Nacimiento River that directly enters Nacimiento Reservoir. EPA is preparing a wide variety of analyses as part of a Superfund Site (Remedial Investigation/Feasibility Study) *to evaluate the delivery and fate of the mercury from the mines. Because mercury binds to sediment and is transported downstream via erosion and sediment transport processes, it is difficult to trace the ultimate fate and amount of mercury that is directly reaching the reservoir.*

General Minerals

Minerals or salts dissolved in water contribute to the total dissolve solid (TDS) load. TDS is typically considered an important measure of water quality from a domestic or agricultural use standpoint. Specific water quality objectives have been established for the waters of the Nacimiento River for various mineral concentrations and TDS. Figure 20 presents the data for these parameters for the period of record, as measured at the "log boom". Overall, the individual constituents that contribute significantly to TDS are within the established water quality objectives. However, there appears to be a slight trend of increasing TDS concentration in Nacimiento Reservoir, especially in the epilimnion. Although it is difficult to determine the causes of an increase in TDS within the reservoir, one possibility to consider is the high evaporation rate off of the lake which may be increasing its long-term salinity as salts and other minerals accumulate in the reservoir. Prior to the reservoir being constructed, these minerals would be transported downstream and either discharge to the ocean or be deposited in floodplain areas. Following dam construction, the reservoir acts as a sink for these minerals and salts, which accumulate in the bottom sediments. A longer period of measurement is needed to determine if there truly is a trend of increasing TDS and what the potential causes may be. The possible trend observed in the existing data may be the result of year-to-year variations in reservoir inflow and seasonal variability.

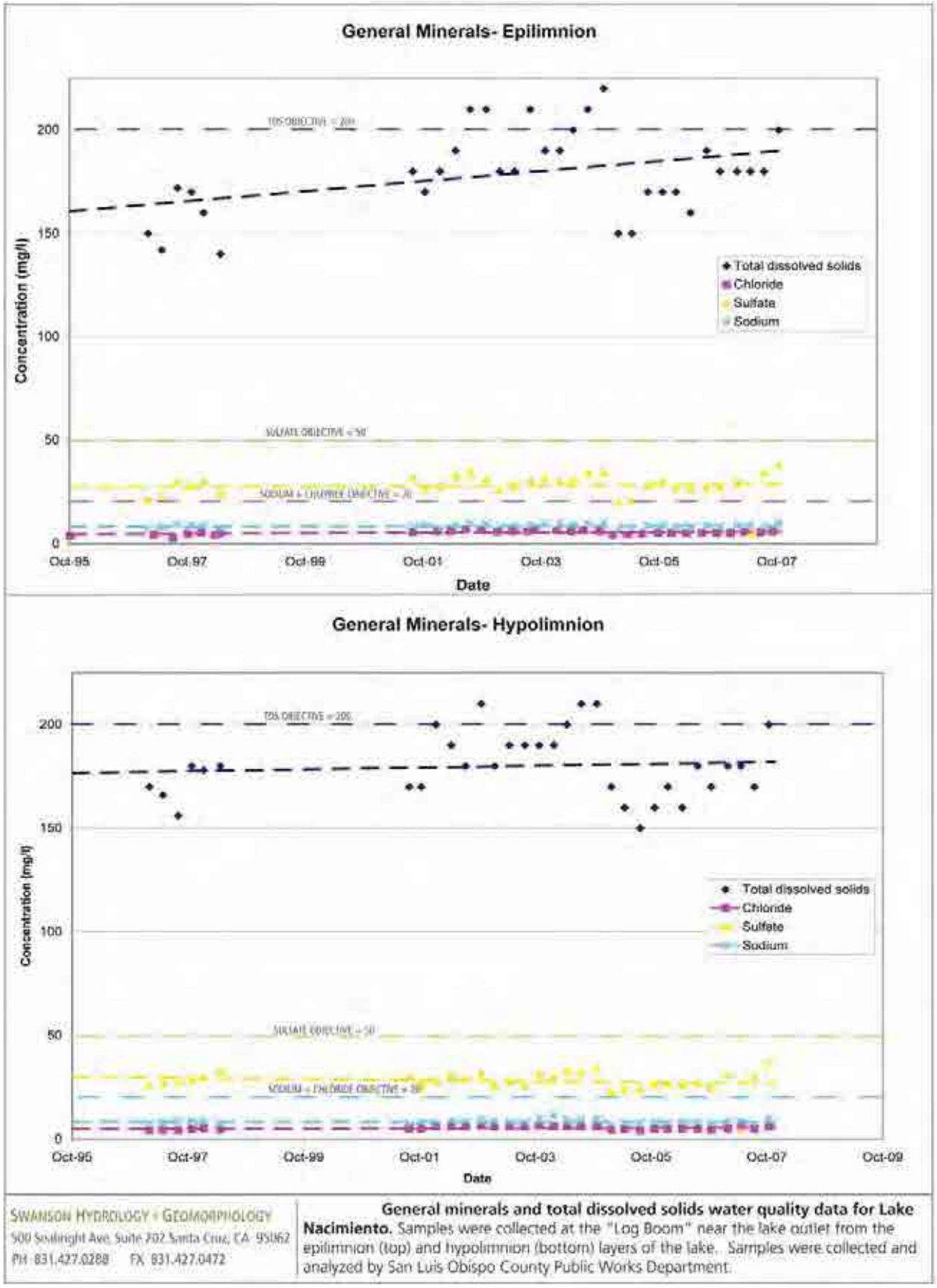


Figure 20. General Minerals and Total Dissolved Oxygen for Lake Nacimiento

Nutrients

High nutrient concentrations in water can degrade or limit nearly all beneficial uses, including aquatic and wildlife-oriented, domestic and agricultural beneficial uses. Figure 21 shows the nutrient data for these parameters for the period of record. There are no established water quality objectives in the Basin Plan for nutrients, but the levels detected in samples taken at the log boom are not likely to adversely impact the beneficial uses listed for the lake.

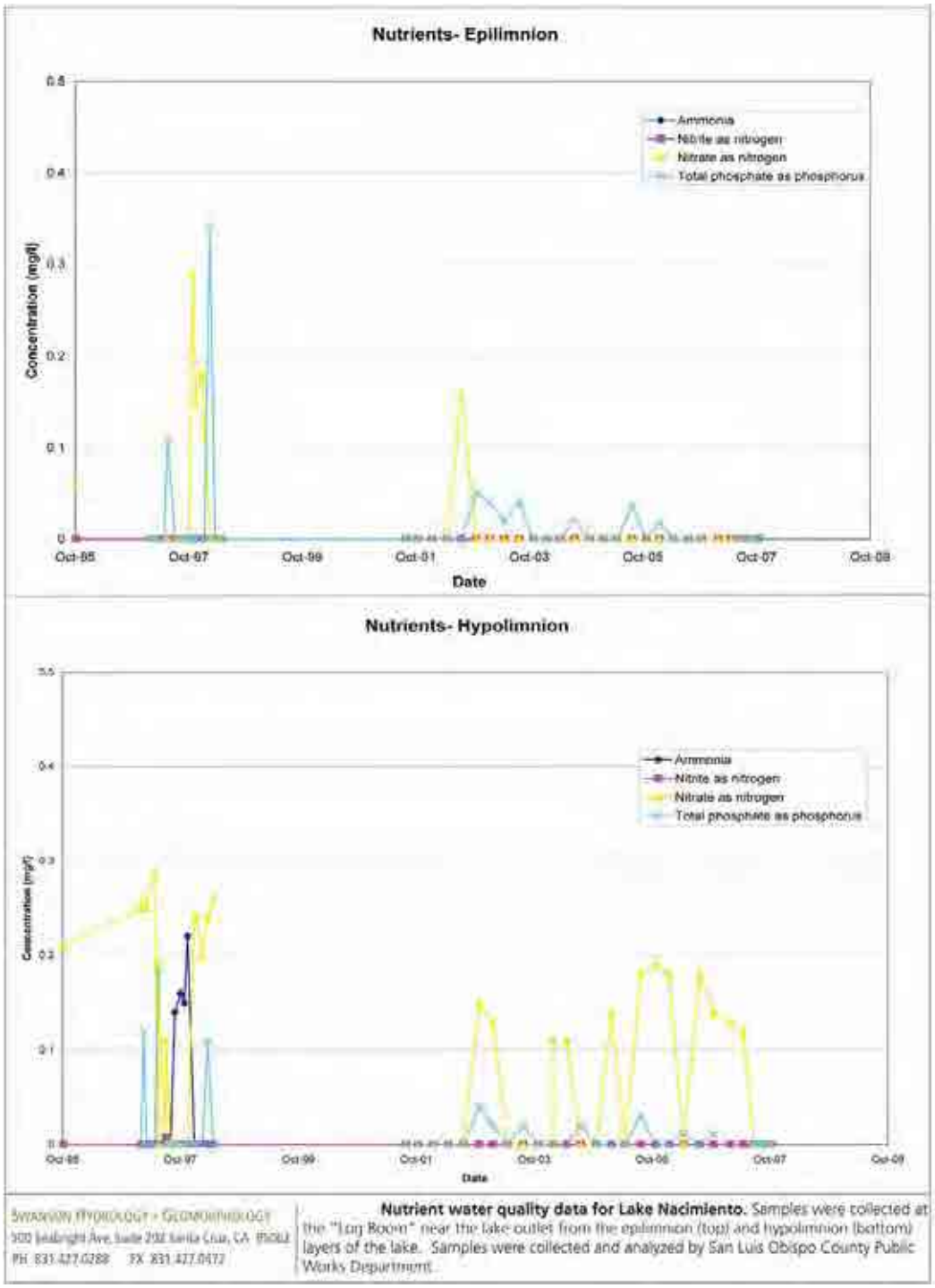


Figure 21. Nutrients for Lake Nacimiento

Anthropogenic Organics

The San Luis Obispo County sampling program tested samples, taken from the epilimnion, for atrazine (an herbicide), simazine (an algicide), MTBE, SOC's (e.g., pesticides, PCBs) and VOC's (volatile organic compounds). MTBE was detected during two sampling events in 2001, but has not been detected since. Bis(2-ethylhexyl)phthalate (DEHP) was detected during two sampling events in 2004, but has not been detected since. The MTBE was detected at relatively low concentrations (5.5 to 14 parts per billion- ppb); [DEHP was detected at 3.2 ug/L and 4/6 ug/L in late 2004. The Maximum Contaminant Level (MCL) for DEHP in finished drinking water is 6 ug/L; this is the highest level of a contaminant that is allowed in drinking water. Both values were below this MCL (Lisa Wallender, personal communication, 2008).] *The data suggest that there is no chronic MTBE or DEHP contamination at this sampling station.*

Microorganisms

The SLO County sampling program tests samples taken from the epilimnion and hypolimnion at the log Boom for microbial contamination including total coliform and E. coli concentrations. High coliform and E. coli counts in recreational water bodies can cause human health problems. Figure 22 shows the data for microbial contamination for the period of record. The data show that there are some spikes in total coliform count, but E. coli counts are relatively low.

SH+G indicated that a more robust data set is needed to evaluate the potential impact of microorganisms on the recreational use of Nacimiento Reservoir. They also indicated that sampling locations should be added to test high use swimming areas, especially in the summer months and within lake inlets where poor water circulation is likely.

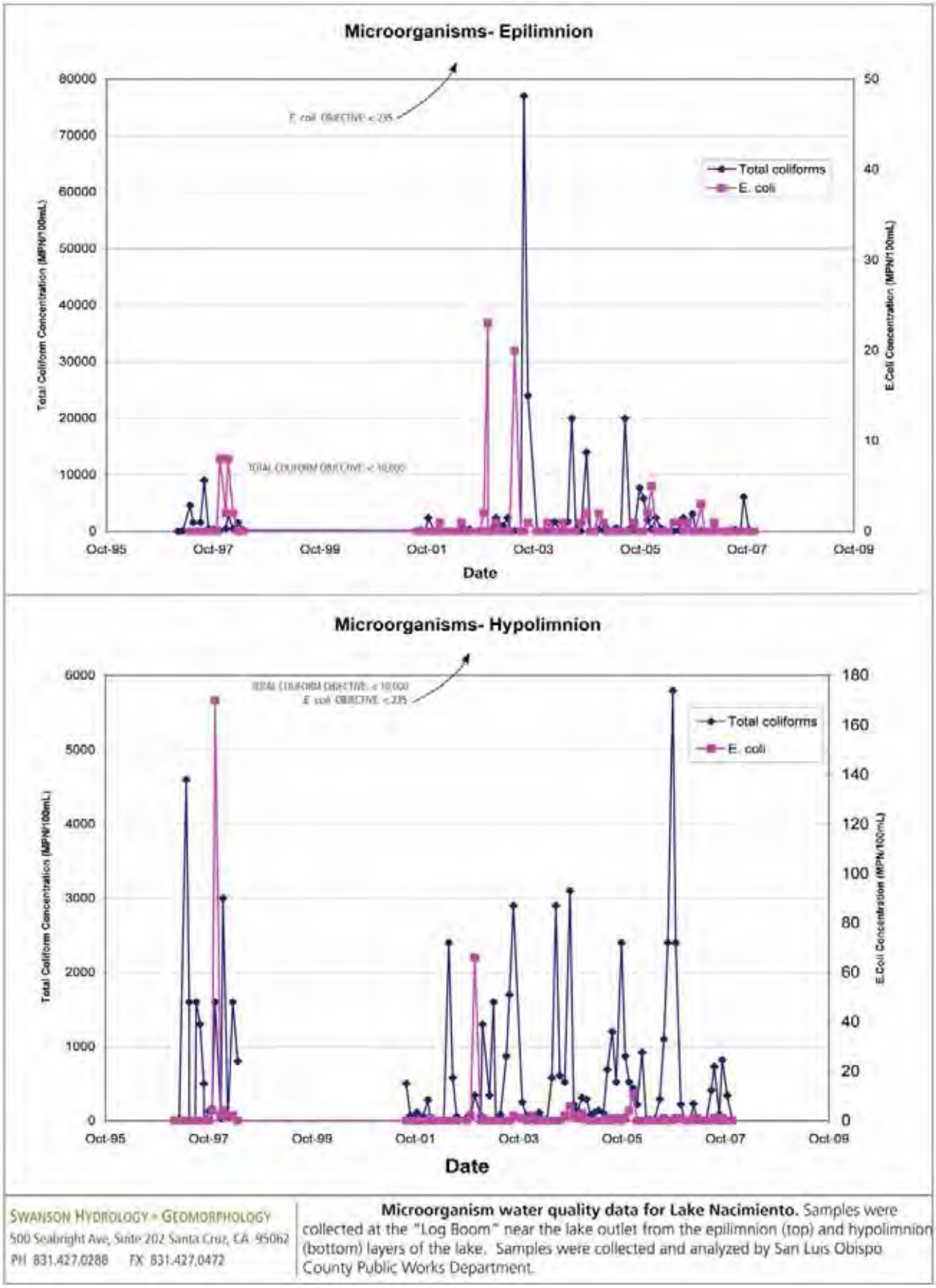


Figure 22. Microorganism Water Quality for Lake Nacimiento

Summary

The log boom data set provides a limited picture of water quality conditions within Lake Nacimiento. Given these limitations, the data suggests that the reservoir supports most of the designated beneficial uses. Temperature and DO concentrations limit the "cold fresh water habitat" beneficial use, but this is due to the physical structure of the lake and remediating this condition would be difficult, if not impossible. The data set collected at the log boom should be extended to other areas of the reservoir to provide a more comprehensive view of water quality conditions in Nacimiento that is both spatial and temporally relevant.

It is important to note that the data analyzed by Swanson Hydrology and Geomorphology was from samples taken at the log boom. Values for many constituents could be different for samples collected at other reservoir locations. An absence of problems in samples collected at the log boom does not necessarily mean there is an absence of problems in other areas of the reservoir.

Surface Water Monitoring Programs

The following is a synopsis of water quality monitoring programs that are either currently occurring or have occurred in the past.

San Antonio River watershed

The Monterey County Water Resources Agency (MCWRA) twice annually monitors reservoir surface water at the dam for dissolved oxygen (DO), temperature, nutrients and general minerals. Tributary surface water is also monitored for general mineral, nutrient, DO and metals (Conrad, 2001). Sampling for bacteria does not currently occur for San Antonio Reservoir.

Nacimiento River watershed

The MCWRA twice annually monitors reservoir surface water at the dam for dissolved oxygen (DO), temperature, nutrients and general minerals. Tributary surface water is also monitored for general mineral, nutrient, DO and metals (Conrad, 2001).

Heritage Ranch Community Services District

Testing for the presence of Methyl Tertiary-Butyl Ether (MTBE) at the Nacimiento River intake downstream of the dam has been part of the Heritage Ranch Community Service District's test protocol since 1996 for organic chemicals.

San Luis Obispo County Flood Control and Water Conservation District

The SLO County Flood Control and Water Conservation District (SLO District) through the Public Works Department Water Quality Lab monitors for physical parameters, general minerals, inorganics, volatile organic compounds (VOC),semi-volatile organic compounds (SOC), and other parameters at the log boom (about 1000 feet out from the dam).

Other Monitoring

Central Coast Regional Water Quality Control Board

The Central Coast Ambient Monitoring Program (CCAMP) is the Central Coast Regional Water Quality Control Board's (CCRWQCB) regionally scaled water quality monitoring and assessment program. Water quality data for the watersheds from CCAMP is available on the CCAMP web site (http://www.ccamp.org/ca300/3/3.htm). In addition, CCAMP staff is developing a multi metric "Health Index" that can be used to describe riparian and overall watershed health. Finally, the RWQCB groundwater clean-up program is ledged on Geotracker, which is a statewide environmental data information management system that tracks Leaking Underground Storage Tanks (LUST) sites.

Citizen Monitoring Programs

The Upper Salinas Watershed Coalition, the Coastal Watershed Council and the Ventana Wilderness Alliance are monitoring in surrounding subwatersheds according to the 2001 Salinas River Watershed: Status of Citizen Monitoring by the Coastal Watershed Council. (http://www.coastal-watershed.org/).

Central Coast Water Quality Data Synthesis Assessment and Management Project

The Monterey Bay National Marine Sanctuary is currently engaged in developing the Central Coast Water Quality Data Synthesis Assessment and Management Project (SAM). Implementation of the SAM project began on June 1, 2006, in order to facilitate region-wide water quality monitoring coordination, data dissemination, data management, and data analysis on the Central Coast of California. A 14-member Technical Advisory Committee (TAC) of water quality experts from around the state was formed to direct the activities of the SAM project. Water quality data was collected from 13 monitoring programs on the Central Coast and collated into a water quality relational water quality database with spatial fields that are coupled to a Geographic Information System (GIS). The database facilitates data dissemination and data analysis; including mapping and comparison with other spatially referenced data sets (Central Coast Water Quality Assessment, Conley, 2008). This program is listed here to alert those conducting water quality monitoring in the Nacitone watersheds so that they can consider collaborating with SAM to enter existing and future water quality data sets for the Nacimiento and San Antonio River watersheds.

Fort Hunter Liggett Water Quality Monitoring

Much of the Fort Hunter Liggett (FHL) installation boundary on the western side follows the coast ridge, so that virtually all rainfall to the installation is within the Nacimiento River or San Antonio River watersheds. Under the State Water Resources Control Board (SWRCB), Water Quality Order No. 97-03-DWQ, National Pollutant Discharge Elimination System (NPDES), General Stormwater Permit No. CAS000001, FHL monitors storm runoff for pH, specific conductivity (SC or EC), total organic carbon (TOC), total suspended solids (TSS), plus volatile and semi-volatile organic compounds, and heavy metals. This monitoring is in accordance with the Storm Water Monitoring Plan, U.S. Army, Fort Hunter Liggett, February 8, 1995 (FHL INRMP, 2004). Runoff is monitored at five points within the Cantonment area for petroleum, pH, volatile organic compounds, and total suspended solids. Points that are monitored for stormwater events are located on the San Antonio River at Nacimiento Road and at Sam Jones Road. Monitoring of total suspended solids, in particular, is important because it reflects erosion.

Surface water and groundwater quality has been measured to some extent since at least 1984 when the current hydrogeological study was completed (FHL INRMP, 2004). Water quality data prior to 1984 are intermittent and are not suitable for comparisons. Water samples obtained during the 1984 study, for several areas of the installation, may be used as a baseline. In order to infer whether water quality has changed since that study, we must focus on analytical parameters that were monitored during and subsequent to that baseline event.

Camp Roberts Water Quality Monitoring

As of a 2000 Camp Robert's Integrated Natural Resource Management Plan, eight monitoring sites at Camp Roberts were being monitored for pH, total suspended solids, specific conductance, oil and grease; one site was monitored for Total Kjeldahl nitrogen; one site was monitored for iron; and five sites were monitored for total and soluble lead. The annual report to the RWQCB was to be prepared and submitted by July 1 of each year. The report was to document the program results for the previous water year (July 1 through June 30). In addition, a water quality monitoring study is to be completed by Camp Roberts during their five-year planning period in concert with Stormwater monitoring program and aquatic habitat surveys.

Water quality was monitored by the USGS on the Salinas River (USGS 11150500 Salinas River near Bradley, California), 7.6 miles downstream of Bradley. Bradley is located near the northwestern corner of Camp Roberts at the confluence of the Salinas and San Antonio Rivers, both of which run through the training site. In general, water quality is acceptable for most uses. Nitrate levels range up to 5 mg/l as N. Calcium and sodium are the predominant cations. Levels of total dissolved solids and selenium are relatively high and approach the maximum acceptable levels determined by the Regional Water Quality Control Board and EPA. However, these constituents occur naturally in the Salinas and San Antonio Rivers. Intensive surveys of both rivers are needed (Camp Roberts Integrated Natural Resource Management Plan, 2000).

Groundwater Monitoring Programs

<u>San Antonio River watershed</u>

Monterey County Water Resources Agency, formerly known as the Monterey County Flood Control and Water Conservation District (MCFCWCD) collected data on a monthly basis for 10 wells in the Lockwood Valley area. General mineral water quality analyses were performed on two to three of these wells annually (Geotechnical Consultants, Inc., 1984).

The primary water type in the Lockwood groundwater basin is bicarbonate type with calcium and magnesium cations (DWR Bulletin 118, 2004 Update). The Monterey County General Plan (1982) describes the water in the area as being both good and plentiful, although the water is highly mineralized. The water is not contaminated by nitrates or tainted by sulfur.

<u>Nacimiento River watershed</u>

The 2003 San Luis Obispo General Plan Land Use Element/Circulation annual resource summary report indicated that the Paso Robles Basin groundwater quality is exhibiting increasing total dissolved solids (TDS) along the urbanized Salinas corridor, near San Miguel, and near the confluence of the Salinas River and Nacimiento Rivers. Increasing chlorides are also noted near the Salinas/Nacimiento River confluence. An understanding of whether upstream land uses are contributing to increasing chlorides would be useful.

Fort Hunter Liggett

According to the FHL INRMP, groundwater monitoring was reported for the period of 1997-2002 with a baseline established in 1984. Many chemical and physical parameters were analyzed for samples taken from shallow well 236 and provided in Table 9 of the INRMP.

> *For these general chemical and physical parameters, there has been no significant change in the shallow groundwater quality. Those compounds that have established Maximum Contaminant Levels (MCLs) for drinking water are present in concentrations far below those MCLs. Data for organic and metal compounds are not presented, due to the lack of baseline data. However, there are no known occurrences of organic compounds in the groundwater from Well 236 and only minor detections of normally occurring metals. This would indicate that military activities are not currently affecting groundwater quality.*

<u>The INRMP section on groundwater quality concludes that:</u>

> *Although military activities within the Cantonment and in field training areas have the potential to impact both surface and groundwater, data available to date suggest that water quality on FHL has not been impaired. Further data may be needed to define sediment and the nutrient loads in the headwaters (outside of FHL influence) of both the San Antonio and the Nacimiento rivers in order to assess effects of military activities for those parameters. Normal ongoing review and implementation of the Stormwater Monitoring Program will continue to identify and reduce possible contaminant sources of storm-water.*

Camp Roberts

Groundwater quality is generally considered to be acceptable for its designated uses (see designated beneficial uses for Camp Roberts below). No bacteria have been detected in water pumped from the wells at Camp Roberts; however, well water that is used for domestic purposes is treated with chlorine as a precaution. No other treatment has been necessary.

Calcium and sodium are the predominant cations found in the Camp Roberts training site's groundwater. Groundwater is also high in total dissolved solids (boron, calcium, sodium, magnesium, and iron).

Thirty groundwater monitoring wells are located at potential sources of contamination, such as the landfill and the Wastewater Treatment Plant. A number of these test wells are associated with remediation sites, such as a fuel facility, Building No. 936, where underground storage tanks have been removed. Most are monitored quarterly. Under regulations by the Regional Water Quality Control Board, wells to the north and south of the Wastewater Treatment Plant are tested monthly (CR INRMP, 2000).

Fish Tissue Monitoring

The California Department of Fish and Game sampled Nacimento Reservoir as part of the Statewide Lakes Study during the summer of 2008. The sampling consisted of one composite sample of carp tested for organochlorine pesticides, PCBs and PPDEs. Also collected were composite samples of small mouth bass and carp for mercury analysis. Final data will be available by the end of 2008 (Mary Adams (RWQCB), personal communications, 2008.)

D. Watershed Uses

General land use descriptions

In 1994, land use in the Nacimiento River watershed was cited as about 50% grazing, 47% open space, 1% housing, 1% camping and 1% inactive mines (Clean Lakes Assistance Program for Lake Nacimiento, 1994).

Agriculture is the primary land use in the watersheds with grazing and dry land farming as the primary agricultural land use. Vineyards and wineries are becoming increasingly economically vital. Residential suburban development is primarily located around Nacimiento Reservoir within the communities of Heritage Ranch and Oak Shores. Residential suburban development varies in density from low to high density with some areas of Heritage Ranch and Oak Shores having residential suburban zoning lots sizes as small as 10,000 or less square feet.

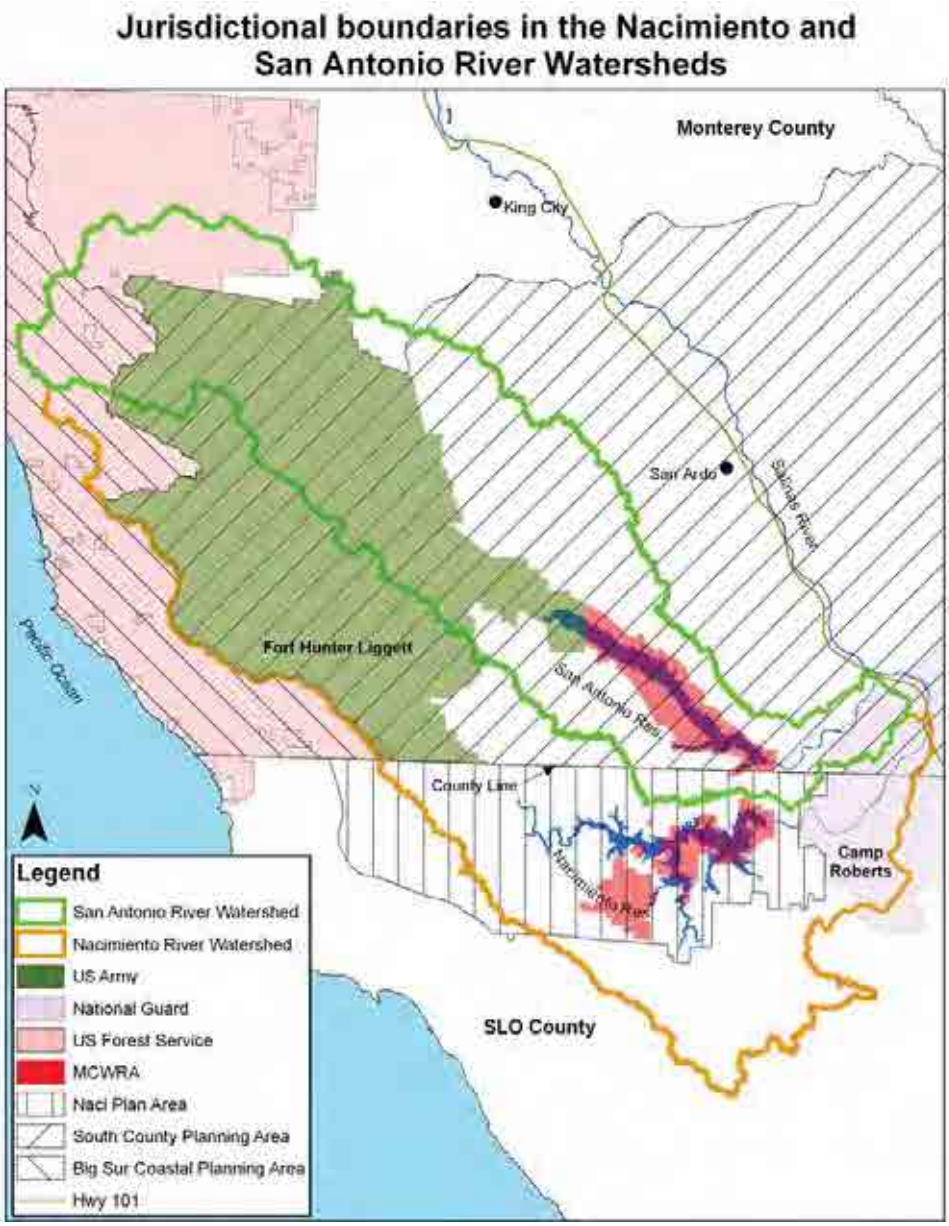


Figure 23. Planning areas in the Nacimiento and San Antonio River Watersheds

Despite the rugged terrain of most of the Nacimiento Planning Area and the concentration of recreational activities at the reservoir, the economy of the region surrounding Nacimiento Reservoir remains based upon agriculture. Grazing is the primary agricultural pursuit, though some dry farming occurs in limited areas as does raising horses and commercial hunting on private property (French, personal communication, 2008). Commercial activities around the reservoir are mostly visitor-serving, and oriented toward peak-use periods. While the role of recreational and visitor-serving commercial activities will experience gradually increasing importance in the planning area economy as development around the reservoir intensifies, the planning area is unlikely to develop a discrete employment base within the term of this plan (Nacimiento Area Plan, 2003).

Farming and Ranching

The San Antonio Valley and the Adelaide portion of the Nacimiento watershed are the primary cultivated agriculture areas of these watersheds. Rangeland used for animal grazing and in some areas hunting and fishing, covers approximately 50% of the land in these watersheds including military and MCWRA lands. This section describes the existing conditions of cultivated agriculture and rangeland management as they relate to water quality and watershed health. It is important to understand how this vital part of the local economy and environment operates in order to identify implementations or recommendations that might be effective to meet the goal of protecting water quality in these watersheds.

AGRICULTURAL CROP PRODUCTION

Agriculture in these watersheds continues to change just as it does statewide. However, rangeland comprises the majority of agricultural acres with grain crops, wine-grapes, and tree crops making up the bulk of the acres. Other crops are also grown with acreage varying depending on the year. These other crops can include: spring salad mix, spinach, tomatoes, cantaloupe, herbs, lettuce, strawberries, almonds, apples, apricots, artichokes, olives, pumpkins, and outdoor plants. Vineyard production in these watersheds has changed over the past 10 years. The San Antonio Valley wine appellation was established in 2007 with approximately 15 vintners (wine makers) and growers. Between the San Antonio reservoir dam and the Salinas River lies the Hames Valley with vineyards and several hundred acres of vegetable crops.

	Acres recorded by Monterey County Agricultural Commissioner	Grains	Grapes	Rangeland	Tree crops	Acreage represented by these crops
2006	**58,317**	1,556	1,283	45,957	79.5	
		2.67%	2.2%	78.8%	0.14%	**99.08%**

Source: Monterey County Agriculture Commissioner's office

Figure 24a. Acres of Top Agricultural Commodities in the San Antonio Valley, Monterey County

	Total Crop Acres	Grains	Wine grapes	Rangeland	Tree crops	Uncultivated/ non crop acres	Rotational	Pastureland
2006	8,926.92	1,686	1,010	3,507	954	650	820	210
2007	8,186.92	none recorded	1,040	none recorded	1,003	3,987*	1,906	210

* 3,147 of these acres are categorized as "undeclared"

Source: Crop report data provided by San Luis Obispo County Agricultural Commissioner's office

Figure 24b. Acres of Top Agricultural Commodities in the Nacimiento Watershed, San Luis Obispo County

Water quality regulation in place throughout the Central Coast applies to all commercially sold, irrigated agricultural crops. As of July 2004, operators of these croplands were responsible for enrolling into a Conditional Agriculture Waiver program and complying with conditions to prevent the cause, or contribution to, the degradation of water quality. Between 2001 and 2005, in both Monterey and San Luis Obispo counties approximately 90% of irrigated agricultural operators completed 15 hours of continuing education specifically focused on water quality protection practices across the following four management areas:

- Irrigation (management, efficiency)
- Fertilization (management, handling)
- Sediment (erosion control, soil health)
- Pesticides (integrated pest management, handling)

Under the Conditional Waiver Program, each irrigated agricultural operator is required to have a Farm Water Quality Plan and provide updated information to the Regional Water Quality Control Board on an annual or bi-annual basis. The Regional Board began conducting field visits to randomly selected program enrollees in 2007 and will subsequently focus on non-enrolled operators. Participants in the Conditional Agricultural Waiver also pay annually for monthly water quality data collection and interpretation conducted by a third party entity and submitted to the Regional Board. None of the current monitoring locations under this program are in the Nacitone watersheds since none of their waterways or water bodies are listed as impaired for agriculturally related pollutants. There is some irrigated agricultural land immediately adjacent to the San Antonio River below the dam. Farmers in the San Antonio Valley and Adelaide area have completed their Conditional Agricultural Waiver requirements and are actively engaged with their local Farm Bureau and Farm Centers to receive any additional information as it becomes available.

Williamson Act Agricultural Lands

The California Land Conservation Act of 1965, commonly referred to as the Williamson Act, enables local governments to enter into contracts with private landowners for restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments that are much lower than normal because they are based upon farming and open space uses as opposed to full market value. Nearly 16.9 million of the state's 29 million acres of farm and ranch land are currently protected under the Williamson Act. Land in Williamson Act protection for the Nacitone watersheds for which information was available is provided in Figure 25a.

Monterey County	Land Use	Acres
	Grazing	24,693
	Vineyards/Orchards	796
	Row Crops	1,032
	TOTAL	26,521
San Luis Obispo County	Conservation Acreage,	81.75
	Transfer of Development Credit (TDC) Program–	5,600
	Grizzly Bend to Monterey Co. line	8,000
	TOTAL	13,682

Sources: SLO County Land Conservancy, Ventana Wilderness Society

Figure 25a. Williamson Act Lands for the Nacitone Watersheds

GRAZING

Cattle, sheep and horse grazing began in the San Antonio Valley when Mission San Antonio de Padua was founded by Fray Junipero Serra in 1771; growing crops began at the same time. The cattle were raised for their hides and tallow which were shipped to Spain. The missions were secularized by the government of Mexico in 1831, and the mission lands were taken from the Franciscan friars and given to the church. Between 1834 and 1846 soldiers and friends of the Mexican government were given land grants. Three had the San Antonio River flowing through them: Milpitas (a milpa is a planted field, milpitas means little fields or gardens), Los Ojitos (little eyes or springs), was granted to Mariano Soberanes, and El Plieto (litigation or dispute). El Piojo (louse) and San Miguelito de Trinidad were near the Nacimiento River. These lands encompassed 115,000 acres of land, used for grazing. The "Californios" lived a colorful life, with vast herds of cattle roaming the rich grasslands. When the Americans took over California in 1848, the grants were open to litigation and some went to heirs of the Californios, some were bought up by rich outsiders. Some ranchos were bought piece by piece by William Pinkerton, James Bolton, William Earl, Faxon Atherton and others. A drought in the mid-1860's killed many cattle. Homesteaders arrived in the late 1870's and more land was devoted to crops. Descendants of homesteaders Ethelbert Sanders Harris, Jan Henry Martinus, Willlian Augustus Weferling, George Christian Heinsen, B. F. Patterson, Edward Gillett, Gottlieb Roth, John Park Hamilton Smith and others farm and ranch in the area today (Raycraft and Beckett, 2006 and Fisher, 1945).

Grazing now occurs on both private and public lands. The acreage of land use dedicated to grazing is approximately 50% of the Nacimiento and San Antonio watersheds including military and MCWRA ground (Coastal Resources Institute, 1994). Currently available data on cattle numbers, location and grazing and land management practices on private lands in these watersheds are spotty. More and better information is needed to maximize improved resource management benefits.

Grazing as a Management Tool

Grazing can be a beneficial tool for the management of invasive and native plant species, for fire management and for improving habitat for threatened and endangered species, all of which contributes to a healthy watershed.

According to a University of California Cooperative Extension (UCCE) article entitled "UC Cooperative Extension Helps Bring Cattle Grazing Back to Bay Area Grassland" (February 2007), farm advisor Sheila Barry, who has researched the modern evolution of California grasslands and low impact rangeland management techniques, discusses the benefits of grazing.

> *…a major benefit of grazing open grassland is fire fuel management, Barry said. However, she believes an even more important driver is improving the habitat for threatened and endangered species, such as the red-legged frog, the California tiger salamander, the Western burrowing owl and the golden eagle.*
>
> *Even insects profit from grazing. Barry considers the Bay Checkerspot Butterfly to be the "poster child of grazing benefits."*
>
> *"It's a classic story," she said. "The only remaining populations of this butterfly are on grazed lands. In areas that were specifically set up for conservation and where cattle grazing was eliminated, the butterfly populations have disappeared."*
>
> *Grazing is managed by controlling season of use and intensity, especially in sensitive areas. Livestock water, supplemental feed and salt are used to control grazing distribution. Barry has been collaborating on a USDA-funded research project with other advisors and UC range specialist Mel George to further understand the effectiveness of livestock distribution in working towards resource management objectives. The project, known as "Cows in Space," uses global positioning collars to monitor the location of livestock on rangeland pastures at the Sierra Foothill Research and Extension Center in Browns Valley, Yuba County.*
>
> *Barry credits ranchers' efforts over the years to implement conservation-minded management practices for illustrating the benefits of grazing to control vegetation and preserve wildlife habitat on public land. "These land management agencies are conscientious about the total ecosystem impact from grazing," Barry said, "just as ranchers have been for decades."*

According to nativehabitat.org, cattle stimulate plant growth and increase annual forage yield by grazing. Through their urine and feces, cattle recycle nitrogen, phosphorus, potassium and other plant nutrients and return them to the soil. By trampling plants that have grown too coarse and brittle to eat, cattle increase the amount of litter on the ground. (This reduces soil and water erosion and helps increase the amount of water that enters the ground and aquifers.) When properly managed cattle convert solar energy captured by native grasses into a sustainable source of meat, leather and other valuable products for human consumption.

According to an article entitled "Good Grazing? Advocates say free-range Cattle Can Have Environmental Benefits," in E: The Environmental Magazine (Nov-Dec 2002), and attributed to Steve Rich, a consultant with Higher Ground Associates in Salt Lake City, Utah which works to build bridges between ranchers and environmentalists,

> *"A hoof print is a hole and holes are wonderful things in nature. They collect water, seeds and nutrients. They are shadier and less windy and a heck of good place for seedlings to start. I have done thousands and thousands of samples and hoof prints make up more than 90% of seedling germination sites."*
>
> *This claim is backed by such evidence as a 1998 Colorado State University study that found biodiversity to be highest in moderately grazed lands and lower under heavy grazing, but lowest of all on ungrazed lands* (Proctor, 2002).

In addition to providing traditional products as meat, leather, tallow and more, well managed range lands and private ranch lands support healthy watersheds, recreational opportunities and wildlife habitat.

According to an article depicting a speech by R.L. Dahrymple at the Missouri Forage and Grassland Council 2000 Annual Meeting entitled "Fringe Benefits of Rotational Grazing",

> *Rotational grazing, with adequate recovery periods, increases forage production. Runoff water and water contained in streams and impoundments is clearer and presumably of higher quality for stock and human use.* (Dahrymple, 2000)

Local cattle ranchers in the Nacimiento and San Antonio who practice healthy rotational grazing would like to see more public entities implement and or expand rotational grazing programs, i.e. FHL, Camp Roberts, Monterey County and the U.S. Forestry.

Given the above information and in light of current conditions such as increased urbanization and a threatened food supply, ranchers and environmentalists will need to find a balanced perspective in order to sustain a healthy environment and safe and abundant food supply. The Nacitone watersheds provide an opportunity to develop positive collaborative resource management efforts among ranchers, environmental groups and public agencies.

Grazing in the Nacitone

The grazing areas for which information was reviewed for this Plan include the MCWRA leases around Nacimiento and San Antonio Reservoirs, FHL and Camp Roberts military installations, Los Padres National Forest and private land.

The table below was constructed to further understand the acreages involved with agriculture. For their "rangeland" category, the county Agricultural Commissioners include a mix of private and public ground and may not include all properties actively being grazed. From a total of approximately 451,386 acres in the two watersheds combined, 50% is entrusted to the listed public entities.

Grazed Acres in Both Watersheds					
	Total grazed and non-grazed acres (including acres not in these watersheds)	**Total grazed and non-grazed acres in watersheds**	**GRAZED acres in watersheds**	**GRAZED acres in Nacimiento river watershed**	**GRAZED acres in San Antonio river watershed**
Camp Roberts	42,615	22,975	22,975		
Los Padres	315,510	28,965	2,150	0	2,150
Fort Hunter Liggett	162,355	162,065	0	0	0
Monterey County Water Resources Agency (MCWRA)	23,617	23,617	16,692	8,865	7,827
SubTotal PUBLIC	**543,807**	**237,912**	**41,817**	**8,865**	**9,327**
PRIVATE LAND	NA	213,464 *	?	?	
Totals	NA	451,386			

Figure 25b. Grazed Acres in Both Watersheds

Sources: Geographic Information Systems calculations; information provided by Los Padres National Forest Monterey District (leaseholder).
An alternative source states that Camp Roberts has a total of 26,100 grazed acres which may include land outside of these watersheds.
* This number is the difference between the public acres in this table and total acres of both watersheds combined.

Monterey County Water Resources Agency

The MCWRA owns approximately 24,000 acres (38 square miles) or approximately 5 percent of the land in the Nacitone watersheds. 16,000 of these acres are located around the reservoirs and make up eight separate parcels leased out for cattle grazing since the land was purchased in the 1950's and 1960's. The remainder of the 24,000 acres is in recreational camping areas, grassland and oak forest (USLT RCD, 2008). In 2007, when the MCWRA renewed its grazing leases, they required all lessees to attend a *Ranch Water Quality Short Course* developed and administered by UC Cooperative Extension. The Short Course was conducted in November 2007 by UC Cooperative Extension and contributing partner entities such as the USLT RCD, the Natural Resources Conservation Service (NRCS), UC Davis researchers, the Ag Watershed Coalition of Northern SLO and Southern Santa Barbara counties, and the Nacitone Steering Committee. Current leases on MCWRA land will expire in 2010. The MCWRA Board of Directors may decide to incorporate new requirements into future lease agreements as recommended in a *Grazing Lands Management Plan* prepared by the *Upper Salinas Las Tablas Resource Conservation District* (USLT RCD) which is further described later in this section.

Currently, MCWRA grazing lease contracts contain the following Conservation Goals and Objectives:

1. Protect the water quality and quantity of reservoirs. A goal of the MCWRA is to eliminate access by cattle to reservoir waters as soon as possible.

2. Minimization of fire hazards through vegetative fuel management and responsible livestock management.

3. Preservation of open space for recreation, scenic beauty and education, and preservation of native plants and animals, and biotic communities. All or portions of the MCWRA land, including the Premises, may be made open to the public subject to reasonable restrictions determined by Landlord.

4. Maintenance of rich and productive grassland and oak woodland communities with healthy populations of rare, threatened or endangered vertebrates, significant native grasses, and for components and minimal exotic pest plants.

5. Restoration of degraded vegetation and wildlife habitat.

6. Maintenance of livestock distribution over the premises, to achieve uniform range utilization, reduce overall fire hazard, minimize sacrifice forage areas and meet conservation objectives.

7. A key requirement for any lease will be the completion of a ranch plan within one year of execution of a contract, which will lay out specific measures that will be used on each lease to protect the water quality and quantity of the reservoirs.

At both reservoirs, MCWRA owns four parcels, leased for grazing, located along the shores of the Nacimiento reservoir. There are also other privately held lands with a variety of uses around that reservoir. In contrast, the land around the San Antonio reservoir is owned by MCWRA except for a portion held by FHL, and is divided into another four separate parcels of leased land. Some existing fencing is located below the high water mark. During certain times of the year this means that range livestock and wildlife currently have access to shorelines of

both reservoirs and their tributary streams. Rugged terrain and arid climate make centralized feedlot areas infeasible (Nacimiento Water Supply Report on Recreational Use at Lake Nacimiento, 2002). Seasonal and release-related water level changes result in significant fluctuations in the amount of land available for grazing on these properties.

A *Grazing Lands Management Plan* was prepared for lands owned by the MCWRA by the Upper Salinas Las Tablas Resource Conservation District (USLTRCD), 2008 and is included in its entirety in Appendix C. The Plan was funded through the same grant that funded the Nacitone Watersheds Management Plan and is expected to help the MCWRA establish land management measures for rangeland health and water quality protection on their 16,000 acres of grazed lands located around both reservoirs.
The Grazing Lands Management Plan assesses current grazing and rangeland management practices on those lands and recommends a mix of existing and alternative practices. The Nacitone *Watershed Strategy* contains some of these recommendations that owners of private grazing lands may also find useful as they consider how best to protect downstream water quality and other watershed resources.

The *Grazing Lands Management Plan* recommends livestock grazing as the primary management tool for MCWRA land.

> *The Plan finds that cattle grazing, if conducted properly, can have the following benefits:*
>
> - *Reduces fuel load for potential fires,*
> - *Improves grass regeneration,*
> - *Improves habitat for many animal and plant species,*
> - *Reduces encroachment of noxious weedy species, and undesirable types of plants, and improved maintenance of grasslands and oak woodland diversity.*
>
> (Grazing Lands Management Plan, USLT RCD, page 2)

Fort Hunter Liggett

Grazing has been a significant land use for more than 200 years, since settlement during the Mission Era. Grazing continued on the Hunter Liggett Military Reservation beginning in 1942 with the issuance of leases that did not specify management or conservation practices. The first land management plan was developed in 1948 and periodically revised from 1948 to 1972. Grazing was discontinued in 1991 after a prolonged drought and over-use that resulted in significant resource damage to herbaceous vegetation (Stechman, 1995). In October 1993, land management responsibility for FHL was transferred from Fort Ord to Fort Lewis, Washington. Early in 1994, FHL and Fort Lewis contracted with The Nature Conservancy to produce a comprehensive grazing assessment with recommendations for grazing management consistent with an overall natural resources management plan (Stechman, 1995 and FHL INRMP, 2004). In 2003, a plan for livestock grazing was developed for FHL (Bartolome et al. 2002, 2003). This document was not reviewed by the Nacitone Steering Committee.

The *Integrated Natural Resources Management Plan* prepared for FHL in 2004 and amended in April 2007 describes current challenges with re-establishing grazing on FHL.

> *Livestock grazing was discontinued on FHL in 1991 due to resource degradation from over stocking and utilization combined with six years of extreme drought conditions from 1984 through 1990. Livestock grazing has*

not been allowed since that time because a clear livestock grazing strategy had not been developed that would prevent resource degradation from re-occurring.

Additional complicating issues have emerged which pose significant resource management conflicts, especially with endangered species management and associated critical habitat designations and proposals. Cultural resource protection issues are also present. Additions and rebuilding of existing fence is likely to cause conflicts with the military training mission. Additional staff will be required to adequately plan, conduct, and monitor a grazing program. Funding of a livestock grazing program through lease agreements may be problematic because out-lease revenues are deposited in a Department of Army account and are not dedicated to the installation where the revenue is generated. (INRMP, 2007, page 136).

Fort Hunter Liggett (FHL) is a military installation with a primary mission to train military personnel to fight war. Training is conducted in an individual and collective environment. The Installation mission has significantly changed and grown since commercial livestock grazing was last allowed in the early 1990's. Training activity has increased from an average of 150,000 training days in the early 1990's to approximately 700,000 training days in training year 2008 (October 2007- September 2008). Training levels have spread out throughout the entire year to all parts of the installation and are projected to exceed 1.2 million training days in FY10 and beyond (an 800% increase since 1992).

"The Army's environmental mission is to sustain the environment to enable and support the Army mission and secure the future." Environmental stewardship is conducted through the Integrated Natural Resource Management Plan (INRMP) conservation programs which are coordinated with the Director of Plans Training, Mobilization and Security (DPTMS) to determine optimal mission landscape requirements for supporting mission purposes (AR 200-1). Conservation reimbursable agricultural/grazing out-lease programs are to be compatible with mission requirements and provide a direct benefit to mission and environmental goals.

As the FHL mission continues to expand it is expected that commercial livestock grazing or similar activities would pose unacceptable conflicts with training activities for the foreseeable future. Based on the FHL senior staff's evaluation of the 2004 INRMP goals and objectives and the current/forecasted FHL training mission, commercial livestock grazing is incompatible with that mission. The FHL Command will not pursue further evaluation of a commercial livestock grazing program on FHL during the next INRMP cycle 2009-2013.

Camp Roberts

Livestock grazing has been an important component of the multiple land uses on Camp Roberts for many years. Cattle and sheep have grazed much of the acreage since the military's resumption of livestock grazing in 1942. Livestock grazing has been known to occur on the property for at least 200 years prior to the military's acquisition.

Agricultural lands just east of Camp Roberts are in Conservation Reserve Program contracts with the USDA. These contracts are used to control erosion on highly erodible lands.

Approximately 20,500 acres on the Main Garrison, with a carrying capacity of 5,400 AUM's* each lease year, will be available for sheep grazing for a six-month period between January 1

and June 30. Approximately 5,600 acres on the East Garrison, with a carrying capacity of 2,000 AUM's each lease year, will be available for cattle grazing for a five-month period between January 1 and May 31.

Recent changes to the grazing program have removed 1,500 acres of riparian areas and the river terrace between East Bradley Road and the Salinas River, which contains sensitive cultural sites within the East Garrison, and 6,320 acres of land from the high country along the southwest border of the Main Garrison from grazing. An additional 4,700 acres (Training Area O, north of the Nacimiento River, portions of TA's P and L between the rivers and the impact area, and portions of the cantonment area were formally incorporated into the Main Garrison sheep lease) were added to the lease.

Grazing Restrictions on Camp Roberts

In many areas, banks along the Nacimiento River are steep and unstable. The Nacimiento River riparian ecosystem also contains numerous cultural resource sites. To preserve and protect the integrity of cultural resource sites and riverbanks from degradation, maintain water quality, and preserve native species biodiversity, sheep grazing will not be permitted in the Nacimiento River or in adjacent riparian habitat. Sheep will cross the Nacimiento River only by using the Low Water Bridge. Soils in these locations are steep, rocky and erosive, lack adequate forage, and are not suitable as sheep bedding sites. The majority of known sensitive plant locations on Camp Roberts are located in this region.

Rotational grazing will continue to be practiced on the Main Garrison by limiting sheep pens and shepherd trailers to a 3-day maximum stay in any one location. Rotational grazing distributes grazing more evenly throughout the Main Garrison and prevents overgrazing or overuse of specific areas.

Revenue generated through the grazing leases is reinvested on the installation, usually through maintenance of firebreaks, repair/replacement of fencing, cattle guards, water appurtenances, etc. Supplemental agreements for projects or work to be done are drafted up and made part of the grazing lease, and work is accomplished by the lessee in partial lieu of rent. Grazing revenue collected covers administrative costs of the program, and the program will adhere to appropriate Army Regulations (CR INRNP, 2000)

Camp Roberts Grazing BMPs

- Implement rest-rotation grazing strategies on both garrisons.
- Change livestock entry date to January 1 of each lease year.
- Limit number of animal unit months (AUM's) available.
- Define an AUM equivalent as follows: 1 ovine ewe, ram or weaned lamb = 0.2 AU (un-weaned lambs are not counted); 1 weaned calf to yearling = 0.65 AU; 1 yearling steer or heifer (1-2 years old) = 1.0 AU; 1 cow with (or without) un-weaned calf, heifer > 2years old = 1.0 AU; 1 bull > 2 years old = 1.5 AU.
- Use herding techniques (herders, range riders) to improve animal distribution and use of forage.
- Place salt blocks and feed supplements less than ¼ mile from watering sources and surfaced roads.
- Remove and dispose of dead livestock near watering sources immediately.
- Exclude or intensively manage grazing in sensitive areas (riparian zones, reservoirs, and fairy shrimp plots) and steep and highly erodible areas.

- Maintain intact boundary fences and remove trespassing livestock immediately upon discovery.
- Prohibit cattle and sheep access to Camp Roberts rivers and riparian areas except at designated crossing sites. Provide/develop watering sites away from these areas.
- Maintain adequate plant and ground cover at all times (maintain 75% cover and a minimum of 1000-1200 lbs. Per acre of residual dry matter).

Camp Roberts Rangeland Improvements

Rangeland improvements on the Main Garrison include cool prescribed burn areas for thistle in the southwesterly and Nacimiento River drainage areas. "Cool" burns are preferred for rangeland improvement. Using fire as a tool at Camp Roberts on rangeland should neither take acreage out of forage production nor defer the grazing season and the Camp Roberts Fire Department supports it.

"Cool fire" burns are executed on cooler days with higher levels of humidity and the area burned is done so without a contiguous effect, thereby creating a patchwork appearance between burned and non-burned areas. In a cool burn, the effects of the fire allow for faster recovery of plant populations, less damage is done to seed banks, and the same desired affect of biomass and species composition control can be achieved. Rebuilding of soil mulching and plant cover is improved and takes fewer seasons than with conventional control fires or accidental burns.

Los Padres National Forest

Grazing is also permitted in the Los Padres National Forest including in the Ventana Wilderness in the upper San Antonio River watershed. According to the Assistant Resource Officer for the Monterey District of the United States Forest Service (USFS) and documented in USFS Grazing Permits Parts 1 and 2 on file with the District, there is one active permitted grazing allotment in the San Antonio River watershed and some vacant allotments on the books. The active allotment is referred to as the Upper Milpitas Allotment., It contains two pastures, the Milpitas Pasture and the Wagon Caves Pasture. This allotment includes approximately 2,150 acres. The maximum head as of September 7, 2007 was 90 cows, 90 calves and 6 bulls, with stock on the land seasonally, typically from February to May. The permit for the allotment is effective until September 2017.

There is an Allotment Management Plan that is 40 or more years old. The District utilizes Forest Plan Standards for residual dry matter (RDM) to monitor range conditions and generates allotment-monitoring reports. There is also approximately 10 head of livestock on the Merle Ranch, which is operated by the Forest Service.

Mining

Mining in the watersheds has a long history. The Clean Lake Assistance Report (Coastal Resources Institute, 1994) includes detail of historical districts for mining. The MCWRA has produced a map using a Geographic Information System (GIS) showing mine locations in both watersheds and is included in electronic format in Appendix J (maps). Currently operating mines are limited to the Lime Mountain Quarry. This is an open pit mine located at the top of Lime Mountain in the Nacimiento River watershed. The mine produces high quality limestone and is permitted to mine up to 200,000 tones per year. Williams Hill Mine produces sandstone and shale for decorative rock and is located in the San Antonio River watershed. As mentioned above in the Water Quality section, the Buena Vista and Klau mercury mines are no longer in operation and will require lengthy remediation by the U.S. EPA.

Recreation

Both Nacimiento and San Antonio reservoirs are used for recreational purposes, including fishing, motorized and sail boating, camping, hiking and water skiing/wakeboarding, swimming, wading, and day use (picnics). The Lake Nacimiento Resort, which is owned by Monterey County Water Resources Agency, is zoned recreational.

Nacimiento Reservoir has 165 miles of shoreline that provide a variety of opportunities for day and overnight recreational activities. Although the peak recreational season at the reservoir is between Memorial Day and Labor Day, year-round activities include picnicking, camping, fishing, hiking, swimming, boating, sailing, water-skiing, jet-skiing, and sunbathing. There are several developed recreational areas, both private and public, along the shoreline. The Monterey County Parks Department provides law enforcement and regulation of boating activities. The Parks Department also manages in-lake facilities such as buoys, shallow markers, and floating restrooms. The largest public recreational facility at Nacimiento is the Lake Nacimiento Resort (SVWP EIR, April 2002).

Current facilities managed by the Monterey Parks Department and a private management company at Nacimiento Lake Resort include: a full-service marina, 21 lake shore lodges, 360 improved campsites, a playground, swimming pool, restaurant, hiking trails, hot tubs, country store, picnic area, and boat moorage facilities with approximately 120 marina slips.

There are also privately managed facilities along Nacimiento Reservoir's shoreline. The two largest are the Heritage Ranch and Oak Shores developments, each providing 50 campsites and marinas with approximately 100 boat slips. The facilities are available only to property owners and their guests. In addition to these two developments, a total of approximately 300 additional private docks are provided by the following: Running Deer Ranch, Tri-Counties Boat and Ski Club, Cal-Shasta Boat and Ski Club, South Shore Village, North Shore Boat and Ski Club, and several private individual lakeshore property owners (SVWP EIR, April 2002).

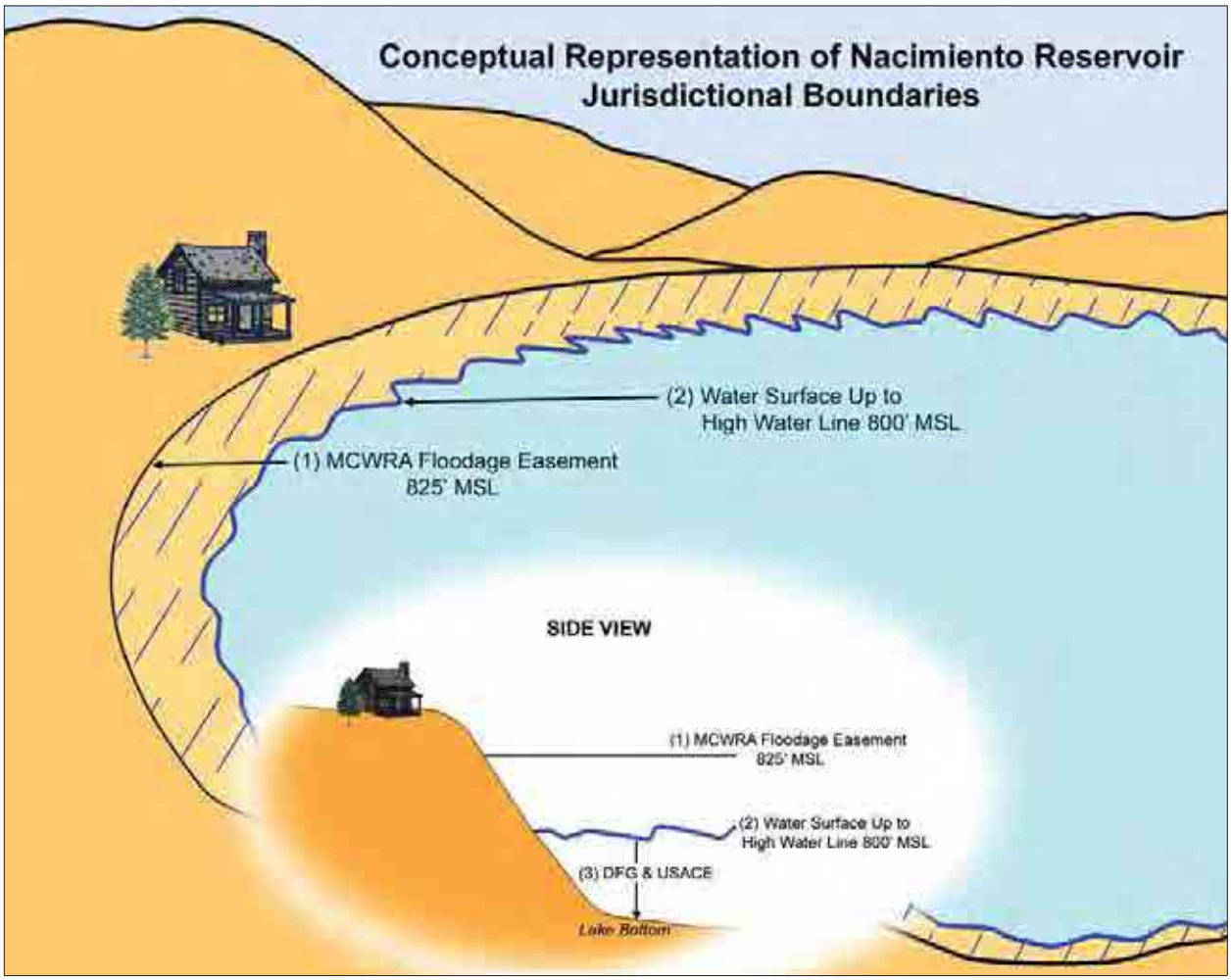


Figure 26. Nacimiento Reservoir Jurisdictional Boundaries

(1) MCWRA owns easement to flood all properties up to 825'Mean Sea Level (MSL) around Nacimiento Reservoir.
(2) Water Surface and on MCWRA land – Monterey Co Parks has law enforcement powers.
(3) State Dept of Fish and Game and U.S. Army Corps of Engineers have permit authority for all work below 800' MSL.

SLO Sheriff Dept has law enforcement powers at all elevations.
SLO Planning Dept has permit authority at all elevations.

Note: Throughout the state the State Water Resources Control Board is charged with preventing water pollution including silt originating at any elevation.

Disclaimer- this diagram is a simplified representation of overlapping jurisdictions which apply to private property located around the Nacimiento Reservoir and is not intended to present a definitive legal opinion.

Private property owners immediately adjacent to Nacimiento Reservoir are subject to a confusing set of multiple jurisdictional boundaries, additional responsibilities, regulations, and reduced property rights. MCWRA owns a floodage easement up to and including the 825′ MSL elevation on all lands around the Nacimiento reservoir. Because the property is located in San Luis Obispo County, law enforcement, health, building and planning regulation falls under that County's jurisdiction. Because the reservoir is designated as "waters of the United Sates", lands around them are subject to California Department of Fish and Game and U.S. Army Corps of Engineers regulation. Disturbance of reservoir bottom or construction below the high-water mark (800′ elevation) requires a consultation with California Department of Fish and Game and might require a permit. Structures, which could impinge on flows of water, may require a U.S. Army Corps of Engineer's permit. It is important to remember that all properties in these watersheds, as well as all lands in the state, are subject to state regulation through the State Water Resources Control Board and the Regional Water Quality Control Board in regards to the protection of water quality. Federal Clean Water Act and various state regulations prohibit the discharge of any pollutant (including silt) into any body of water designated to be "waters of the United States".

Although the landowner does own their entire parcel, some of their property rights were purchased in the 1950's by the Monterey County Water Conservation and Flood Control District (now MCWRA), so that the reservoir could be constructed. The property right held by MCWRA precludes the construction of any development in the easement which would prevent that land from being inundated by reservoir waters. Property owners must allow MCWRA staff entry to the floodage easement located on their property so that they can conduct reservoir maintenance.

San Antonio Reservoir and its 65 miles of shoreline offer year-round recreational activities for the public. Activities at the reservoir include: picnicking, camping, nature study, games at open playfields, fishing, and baseball, horse shoes, hiking, swimming, rafting, boating, sailing, waterskiing, jet-skiing, and sunbathing. Monterey County Parks Department also conducts special events such as the Wildflower Festival and Triathalons, and eagle watch boat tours (January through February).

Recreational facilities at San Antonio's south shore include 3 campground complexes that provide over 500 campsites. A museum, visitor center, park administration office, the Oak Room Group Building and Barbecue area, and over 26 miles of hiking and mountain bike trails can also be found in the south shore area. The South Shore Marina has boats, boat motors, jet skis, and houseboat rentals, as well as bait, tackle and ski accessories. A full service resort at the reservoir has cabin rentals, a store, restaurant, gas station, and marina with boat launch ramps, fish cleaning facilities, and docks. San Antonio's north shore provides opportunities associated with shoreline camping (over 4 miles), the McCandless activity area and outdoor amphitheater, and equestrian activities. The Monterey County Parks Department manages the boating and camping facilities along the lakefront, and a private management company manages the South Shore resort cabins, marina, boat rental, and snack bar facilities.

Los Padres National Forest lands are suitable for a variety of uses. General outdoor recreation activities available in the Nacitone watersheds component of Los Padres Unit includes: hunting, fishing, hiking and camping. Campgrounds with the Nacimiento River watershed include Nacimiento Camp, Ponderosa Camp, ABC and Redwood Spring. San Antonio River watershed campgrounds include Fresno and Carrizo Springs. These campgrounds have primitive facilities including vault toilets, picnic tables, fire rings and barbeque grills. The trail system within the Monterey District of the National Forest is extensive. Portions of the Forest within the Monterey District are designated Wilderness (Ventana Wilderness Area). Motorized vehicles and mountain

biking are not permitted in Wilderness. Additional uses within National Forest lands within the watersheds include watershed function, livestock grazing, and conservation education and stewardship (Part 1 Draft Land Management Plan, USFS, 2004).

During the 1990s, the Army delineated areas within FHL that were excess and deemed surplus. The National Park Service undertook a study to determine the suitability of those lands for inclusion in the National Park System. Though the Army rescinded the order delineating the excess land and subsequent action was not taken for determining National Park status, recent legislation gives the Department of Agriculture (US Forest Service) the right of first refusal on any properties that are determined to be excess to the Army's needs at any time in the future. Thus management for public use and recreation could occur in the future if FHL land is not needed for military use (FHL Special Resource Study, 2006).

The Nacimiento Fergusson Road makes the Nacimiento River one of the few streams in the mountain range easily accessible for recreation, including scenic driving, hiking, swimming, angling and camping. Two roadside Forest Service campgrounds provide good opportunities to explore the river.

Natural and Cultural Attributes

Because their upper watersheds are largely undisturbed, the Nacimiento and San Antonio Rivers are an important source of clean water for Monterey and San Luis Obispo residents, farmers and industries. Their highly productive ecology includes rich riparian habitat, the state's southernmost redwood forests, and the rare Santa Lucia fir (Cone Peak Research Natural Area). Much of the Santa Lucia Range is protected as wilderness which prohibits roads, mechanical/ motorized use and resource extraction. It also requires federal managers to actively preserve the free-flowing nature of the rivers and their unique qualities. There has been a call for additional protection provided by the National Wild and Scenic Rivers System (Ventana Wilderness Alliance, 2007).

The importance of preserving watershed function as source of clean water is further identified in *The Role of Headwater Streams in Downstream Water Quality*.

> *"The results reported here are consistent with the notion that pollutant sources and hydrological and biogeochemical processes in headwaters are physically and bio-chemically connected to the water-quality conditions in downstream waters of widely varying sizes, including navigable waters and their tributaries".*
>
> Alexander, et. al., 2007

Mission San Antonio de Padua, which was founded in 1771 by Father Junipero Serra, is one of the most significant cultural resources in the watersheds. (http://missiontour.org/sanantonio/index.htm) W. R. Hearst's ranch headquarters, the Milpitas Hacienda, situated on a 21-acre site known as "Hacienda Hill" is another significant cultural resource in the area. The architect was Julia Morgan, who designed Hearst Castle. It is located within FHL within walking distance of the Mission San Antonio (FHL Special Resource Study, 2006).

According to the Ventana Wilderness Alliance (VWA) and Friends of the River (FOR), approximately 8.6 miles of the San Antonio River and 9.0 miles of the Nacimiento River are considered suitable for designation as a Wild, Scenic or Recreational River as described in their 2007 pamphlet prepared for the Nacitone Watershed Committee based on heritage and cultural

resource values listed by the US Forest Service (Part 2 USFS, 2004). The VWA and the FOR are actively campaigning for their Ventana Wild and Scenic Rivers Proposal to be introduced into Congress. The Nacimiento and San Antonio Rivers are included in the proposal. Values considered on the Nacimiento River include recreation, wildlife and botanical. Cultural resources, scenery, wildlife, geology and ecology are identified values on the San Antonio. The Forest Service has analyzed these rivers for Wild and Scenic status. They were not recommended as they did not qualify for Wild and Scenic status based on USFS evaluation criteria (FEIS Los Padres National Forest Land and Resource Management Plan, 2005).

The Los Padres Forest Plan established the Milpitas Special Interest Area (SIA), which encompasses 9,948 acres of the upper San Antonio River watershed including both the main stem and North Fork and several tributaries. The area was designated due to its pre-historic and historic cultural resources and ethno-graphic landscape.

The Valley Oak Research Natural Area (108 acres) was also proposed and is within the boundaries of the SIA. It is one of the last remaining stands of Valley Oak savannah on public lands in California. The U.S. Forest Service and the Ventana Wilderness Alliance are collaborating in the development of management plans for these areas.

FHL Land Use

FHL is evenly split between the two watersheds with each comprising approximately 50% of the installation area. Approximately 36% of the watersheds, as measured from headwaters to the confluence of the Salinas River, lie on Fort Hunter Liggett (Ken Ekelund, personal communication, 2007).

Fort Hunter Liggett is an Army Reserve installation and has approximately 150,000 acres of maneuver area suited for vehicle and non-vehicular military training. Fort Hunter Liggett hosts training by all types of Army units as well as units from the Navy, Marines and Air Force and has been designated as a Combat Support Training Center (CSTC). Fort Hunter Liggett has a wide variety of training land available, and includes shrub lands, grasslands, and forests in plains and mountainous settings (DP EIS, 2007).

FHL is currently under federal ownership, managed as part of the Western Training Center for the US Army Reserve. Military bases are included in the Public/Quasi-public land use category in the Monterey County General Plan (Monterey County 1995 and 2004). As federal land, FHL is not subject to local zoning (FHL Special Resource Study, 2006).

The installation provides large expanses of land required for military training. Some other land uses may be allowed if they do not conflict with the designated and primary land use of military training and are compatible with responsible natural resource stewardship. The many vegetation communities and water resources on FHL are managed to sustain current and future military training through responsible land stewardship and environmental compliance with federal laws such as the Sikes Act, Endangered Species Act, Bald and Golden Eagle Protection Act, Migratory Bird Protection Act and the National Environmental Policy Act. Army Regulation 200-1 guides the implementation of land stewardship and environmental compliance with all mission related activities on the installation. Fort Hunter Liggett Regulation 200-3 requires environmental review of all activities that may affect natural and cultural resources (2007 Annual Report, February 2008).

Military training on FHL that relates to natural resources includes live-fire exercises, field maneuvers, fixed-range firing, aviation, weapons testing, and use of the tank trail that runs

between FHL and Camp Roberts. Operations and maintenance activities that relate to natural resources include road maintenance, fire protection and prescribed burning, pest control, and new construction and ranges (2007 Annual Report, February 2008).

Developed areas of FHL include about 152 ha (H" 376 acres; 0.23%) of the FHL land area. Historic disturbances from training, FHL activities, and pre-military activities are evident in some areas and include the following:

- Presence of roads, facilities, and water developments and impoundments;
- Remnants of historic established bivouac sites and associated use;
- Erosion primarily associated with roads;
- Historically cultivated areas that may alter plant composition;
- Intentional reduction in oak stands in isolated areas during the 1950s;
- Unintentional loss of oak trees in isolated areas, primarily from fires;
- Wetlands created by excavations conducted for concealment (*i.e.* tank hull-down positions);
- Evidence of compacted soils at the Multi-Purpose Range Complex as well as in training areas 2, 3, 12, 15, and 20;
- Evidence of military maneuvers in the Nacimiento River Valley;
- Presence and spread of the noxious weed yellow star-thistle; and
- Conversion of chaparral to grassland and scrub in isolated areas from repeated burning. (FHL INRMP, 2004)

In August 2007, the Army released the Draft Programmatic Environmental Impact Statement (DP EIS) for Army Growth and Force Structure Realignment. A growth scenario for FHL, which may have also affected Camp Roberts, was analyzed for impacts to the environment. Pertinent concerns to this planning effort included water quality, water supply, point and nonpoint sources of pollution, population, and vegetation and habitat. At this writing in September 2008, the Army has elected not to move forward with large-scale FHL expansion but may instead expand on a smaller scale.

There are several non-military in-holdings within the installation: property within the old town of Jolon and the Mission San Antonio de Padua. In-holdings at Jolon include the Tidball Store structure, Saint Luke's Episcopal Church, and Saint Luke's Cemetery. The Tidball Store structure is owned by Monterey County Parks Department, but approximately 1 acre of land under and adjacent to the store is presently owned by the Army and was part of the former excess BRAC property. Mission San Antonio de Padua is on the north side of the cantonment area (which supports urban and administrative functions). The site occupies approximately 85 acres and includes the Mission, residences for clergy, a cemetery, and outbuildings. The Monterey Diocese of the Catholic Church owns the Mission (FHL Special Resource Study, 2006).

Non-military uses on military land include hunting and fishing, non-military housing rentals, and visitation to the non-military in-holdings. FHL is rich in cultural resources including recorded archeological sites, which is on the National Register, and the historic trails of the early Spanish explorers, Portola, Serra and De Anza.

E. Reservoir Features and Management

The MCWRA has licenses, permits and orders from the State Water Resources Control Board to store and/or divert water from the Nacimiento, San Antonio and Salinas Rivers. Those

rights recognize dam storage capacities of 377,900 and 350,000 acre-feet respectively in Nacimiento and San Antonio Reservoirs. Those rights also recognize the agreement between MCWRA and the San Luis Obispo District giving the latter the right to use 17,500 acre-feet annually from Nacimiento Reservoir, less than five percent of that reservoir's storage capacity. A total of 1,750 acre-feet annually is allocated by San Luis Obispo County for use around the reservoir. Additionally, MCWRA has an agreement with the Nacimiento Water Company to allow the Company to use up to 600 acre-feet annually. The Nacimiento Water Project will utilize the balance of the County's allocation in the near future.

San Antonio Reservoir

The San Antonio Reservoir, located in southern Monterey County on the San Antonio River, began operations in 1967. San Antonio Dam is five miles west of Bradley and three miles north of Nacimiento Dam. At full pool, the reservoir has a volume of 335,000 acre-feet, surface elevation of 780 feet, and a maximum depth of 180 feet. There is 65 miles of shoreline. San Antonio Reservoir yields on average about 13% of the total water in the Salinas River System. Average annual release is about 63,000 acre-feet but has been as high as 310,000 acre-feet (SVWP EIR, April 2002).

San Antonio Dam

This earth-fill dam has a height of 201 feet above the streambed and a crest length of 1,433 feet. The crest of the dam is 802 feet above mean sea level (msl) with a spillway crest elevation of 780 feet; the spillway has the capacity to pass a maximum flow of 35,400 cfs. The dam has an outlet works consisting of an 84-inch diameter, 1,085 foot- long steel conduit located near the center of the Dam. The conduit leads through the dam embankment from a small intake structure to an outlet structure, which contains a Howell-Bunger type valve enclosed in a concrete house. The outlet has a maximum capacity of 2,200 cfs when the reservoir elevation is 780 feet. The log boom on the San Antonio Reservoir is intended to prevent boats and debris from becoming trapped in the dam spillway; it is approximately 250 feet in length.

San Antonio Release Information

The MCWRA reports that variable releases from San Antonio Reservoir are made to augment releases made from Nacimiento Reservoir. Together, those releases provide river flow to the Agency's Target Area for end of flow, at approximately River Mile 17 to River Mile 13. Since its construction, the water level in San Antonio Reservoir has only reached the spillway once, in 2006.

Nacimiento Reservoir

Nacimiento Reservoir is located on the Nacimiento River about 18 miles northwest of Paso Robles in San Luis Obispo County. It was created by the construction of the Nacimiento Dam, completed in 1957. The reservoir's irregular shoreline when full comprises about 165 miles. At maximum pool, the reservoir's storage capacity is 377,900 acre-feet with a surface elevation of 800 feet and a surface area of 5,400 acres. The maximum depth of the reservoir is 175 feet, with annual water surface elevations usually ranging from 30 to 70 feet. Nacimiento Reservoir yields on average about 62% of the total water in the Salinas River System.

The key elevations of Nacimiento Reservoir, depicted in the chart below, were compiled by the Monterey County Water Resources Agency and provided to attendees of the Public Advisory Meeting on September 19, 2007. The information provides specific operational components of the reservoir and dam that can occur at various water elevations. There is no corresponding key elevation chart for San Antonio Reservoir.

ELEVATION (feet)	STORAGE (acre-feet)	DESCRIPTION
670.0	10,300	Minimum elevation water can be released from the Low Level Outlet Works, physical minimum pool; lowest possible reservoir elevation water can flow from by gravity.
687.8	22,300	Minimum pool, lowest reservoir elevation at which water is available to the MCWRA for release. The balance remaining up to a maximum of 17,500 acre-feet is reserved for use by the San Luis Obispo County Flood Control and Water Conservation District pursuant to its agreement with MCWRA.
730.0	92,150	Elevation above which most boat ramps around the reservoir are operational
748.0	144,200	Elevation defined in Memorandum of Agreement (MOA) with Fish & Game, below which drought conditions are defined to exist, and the minimum release can be reduced from 25 cfs to 10 cfs
755.0	168,350	Minimum elevation at which water can be released from the High Level Gates
766.5	212,700	Both launch ramps at Nacimiento Reservoir are operational in a range of two to three feet above this elevation
777.3	260,000	Top of the Water Conservation Pool, bottom of the MCWRA Flood Pool
782.5	285,050	Bottom of the Federal Energy Regulatory Commission (FERC) Flood Pool, minimum water surface elevation during January and February without maximum releases being made for post spill way modification construction 2008/2009.
800.0	377,900	Elevation at which Nacimiento Reservoir is considered full, top of spillway, maximum physical permanent water elevation

Figure 27. Key Elevations of Nacimiento Reservoir

Reservoir Infrastructure

(Sources include NACIMIENTO DAM OPERATION POLICY and SAN ANTONIO DAM OPERATION POLICY and "Survey of the San Antonio and Nacimiento Dams and Reservoirs" Prepared by Thomas L. Perry, May 10, 2001 for the Monterey County Water Resources Agency Board of Directors)

Nacimiento Dam

Completed in 1957, this earth-fill dam has a height of 215 feet above the streambed and a crest length of 1,650 feet. The crest length is defined as the length along the top of a dam. The crest elevation is 825′ above mean sea level (msl) with a spillway elevation of 800′. The spillway has the capacity to pass flows up to 70,000 cfs. The High Level Outlet Works (HLOW) is composed of twin 8′ x 8′ square steel slide gates and cast concrete tunnels located under the center of the spillway at an elevation of 755′ (NGVD 1929 datum for all elevations based on this datum).

The HLOW has a maximum capacity of 5,500 cfs when the reservoir elevation is 800′. The Low Level Outlet Works (LLOW) is a 53" diameter pipe located near the southern side of the Dam. The inlet to the LLOW consists of three 42" butterfly valves set in a concrete structure at an elevation of 670′. Releases from the LLOW can be made from either a manifold of six 24" manually operated valves or the Hydroelectric Power Plant. The LLOW has a maximum capacity of 460 cfs when the reservoir elevation is 800′.

An existing 1,900-foot Log Boom on the Nacimiento Reservoir is intended to prevent boats and debris from becoming trapped in the intakes or the spillway. A new log boom, 2413 feet in length, will be installed in 2008 to accommodate a slightly larger exclusion area that will also include the Nacimiento Water Project intake structure.

Floodage Easement

MCWRA holds a "Floodage Easement" on those portions of all private land around the Nacimiento Reservoir, therefore MCWRA has an easement to flood up to 825′ mean sea level and provide MCWRA staff access to private property to perform routine reservoir maintenance.

Nacimiento Release Information

Releases at present range between 120,000-acre-feet and 180,000-acre-feet per year. Releases are utilized for groundwater recharge, reduction of seawater intrusion, and steelhead habitat enhancement. The actual amount released varies with weather conditions groundwater elevations, pumping, system hydrology, and other factors.. Whenever the reservoir level rises above 782.5, the high level gates located on the spillway have been used to release water.

The low level outlet is the primary outlet for releases. The capacity of the outlet is approximately 400 cubic feet per second (cfs), when releases flow through the hydroelectric power plant. At water surface elevation 800 feet, maximum capacity is about 460 cfs and at elevation 700 feet, maximum capacity is about 390 cfs.

When the need for releases exceeds the 400 cfs capacity of the low level outlet, releases are made from the high level gates. When the elevation is below 755 feet, releases are not possible from the high level gates and releases are then made from San Antonio Reservoir, if possible and necessary.

Combined Reservoir Features

Nacimiento and San Antonio Reservoirs have water conservation pools that are relatively similar in size: Nacimiento – 245,000 acre-feet (AF) and San Antonio – 282,000 AF. While they are similar in storage capacity, the rate at which they fill is very different. The fill rate, or inflow into the respective reservoir depends on a number of variables, including but not limited to orientation of watershed, amount of rainfall, geology, and weather. Nacimiento Reservoir receives a greater amount of inflow than San Antonio, therefore in an average year; more water is released from Nacimiento than San Antonio. This way, there is room in Nacimiento for the next year's storms. In addition, because there is a power plant below Nacimiento Dam, there are federal limits on how much water can be stored behind the dam (this maximum elevation changes throughout the year, depending on the month). This maximum elevation, or Rule Curve, is in place for the protection of the dam itself, as well as the power plant below, and through application, minimizes the occurrences of reservoir spill, thus saving the captured

water for other beneficial uses. The minimum storage levels or minimum pools of the reservoirs are 22,300 AF for Nacimiento and 23,000 AF for San Antonio. The difference between full capacity and the conservation and minimum pools on each reservoir is called the flood pool, which is 110,600 AF for Nacimiento and 30,000 AF for San Antonio (Rob Johnson, 2008).

Reservoir Management

The Reservoir Release Schedule is a guide to assist the MCWRA in making water conservation releases from both Nacimiento and San Antonio Dams. Prior to cessation of natural flow in the Salinas River each year, MCWRA staff drafts a Preliminary Reservoir Release Schedule which considers various factors contained in the Dams' Operations Policies. The schedule considers the following priorities: 1) provide maximum groundwater recharge for the entire Salinas Valley, 2) operate the reservoirs to provide recreation benefits, 3) provide for the needs of fish and wildlife, and 4) waste as little water as possible to evaporation or to the ocean. Each spring, usually at its annual April meeting, the Reservoir Operations Committee reviews the Preliminary Release Schedule and recommends a Proposed Release Schedule to the Board of Directors for adoption. The Reservoir Operations Committee reviews the adopted Release Schedule monthly and makes recommendations or changes as needed.

Sediment Supply and Transport

SH+G conducted a preliminary sediment budget for the watersheds to provide insight into the mechanisms and rates for sediment delivery to the reservoirs. This can, in turn, provide watershed stakeholders with information to assist future management scenarios regarding sediment delivery and runoff and for the MCWRA to consider the life spans of the reservoirs. The technical content of the sediment budget is contained in the SH+G technical memorandum (Appendix D). The following are the observations SH+G made regarding the sediment budget.

> *The difference in rates of sediment transport between the two watersheds is striking. San Antonio was estimated to have twice the rate, per unit area, of sediment transport than Nacimiento. Although a complete assessment of sources of sediment in the watershed and a complete accounting of sediment delivery through the use of a sediment budget is out of the scope of this project, some preliminary observation were made using aerial photos and a general understanding of the geology and geomorphology of the watersheds.*
>
> *Landscape Morphology: The morphology of the two watersheds are completely different. The Nacimiento watershed abuts the divide between the Big Sur Coast and the Salinas Valley, reaches higher elevations in the upper watershed, and generally has higher precipitation. Consequently, the Nacimiento watershed has a more dense vegetation canopy dominated by oak. The lowland valleys are generally narrow and more confined. Conversely, the San Antonio Creek watershed is dryer, and has less vegetation. The lowland areas are dominated by a large alluvial plain known as Lockwood Valley and the San Antonio River valley is less confined.*
>
> *Sediment Supply: The quantity of sediment passing a particular point in the watershed is dependent upon the supply of sediment from the adjacent landscape to the channel. In the case of San Antonio, the readily available supply of sediment on the adjacent landscape far exceeds the quantity of sediment that is available in Nacimiento. Most of the sediment available for erosion in Nacimiento consists of recently weather colluvial*

material and a narrow band of alluvial material within the river valleys. In San Antonio, Lockwood Valley provides a huge source of highly erodible material that consists of unconsolidated alluvial fan deposits emanating from the mountains from the north and east. In addition, there are extensive, recent alluvial deposits within the San Antonio River floodplain that are easily reactivated during a high flow event or as a result of bank erosion.

Land Use: Land uses in the San Antonio watershed tend to be higher intensity and more prone to create conditions that increase sediment supply to channels. Agriculture, grazing, and residential development within Lockwood Valley all provide a mechanism for sediment delivery that isn't as prevalent in the Nacimiento watershed.

Under natural conditions, assuming anthropogenic inputs were not a factor; the San Antonio River would have a higher sediment load than the Nacimiento River. The geologic differences, morphology of the basin, and a good supply of highly erodible material make the watershed more productive for sediment. The most significant sources of sediment within both watersheds appear to be reactivation of previously deposited alluvial materials and fire-dependent influxes of sediment from the upper watershed. San Antonio also has a significant land use component that adds additional sediment to the channels, although calculating the exact contribution from these sources would require a thorough evaluation.

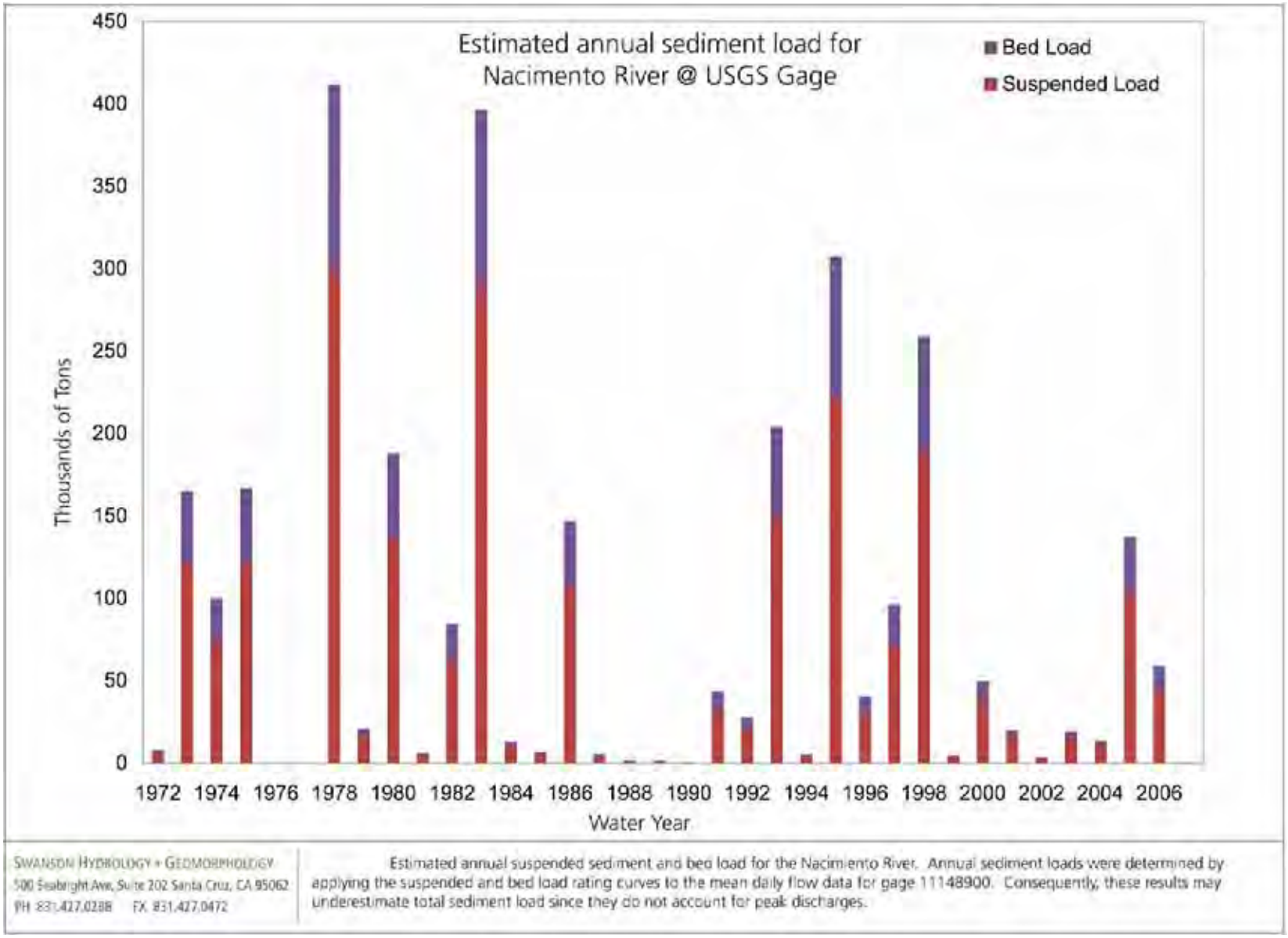


Figure 28. Estimated Annual Sediment Load for Nacimiento and San Antonio Rivers

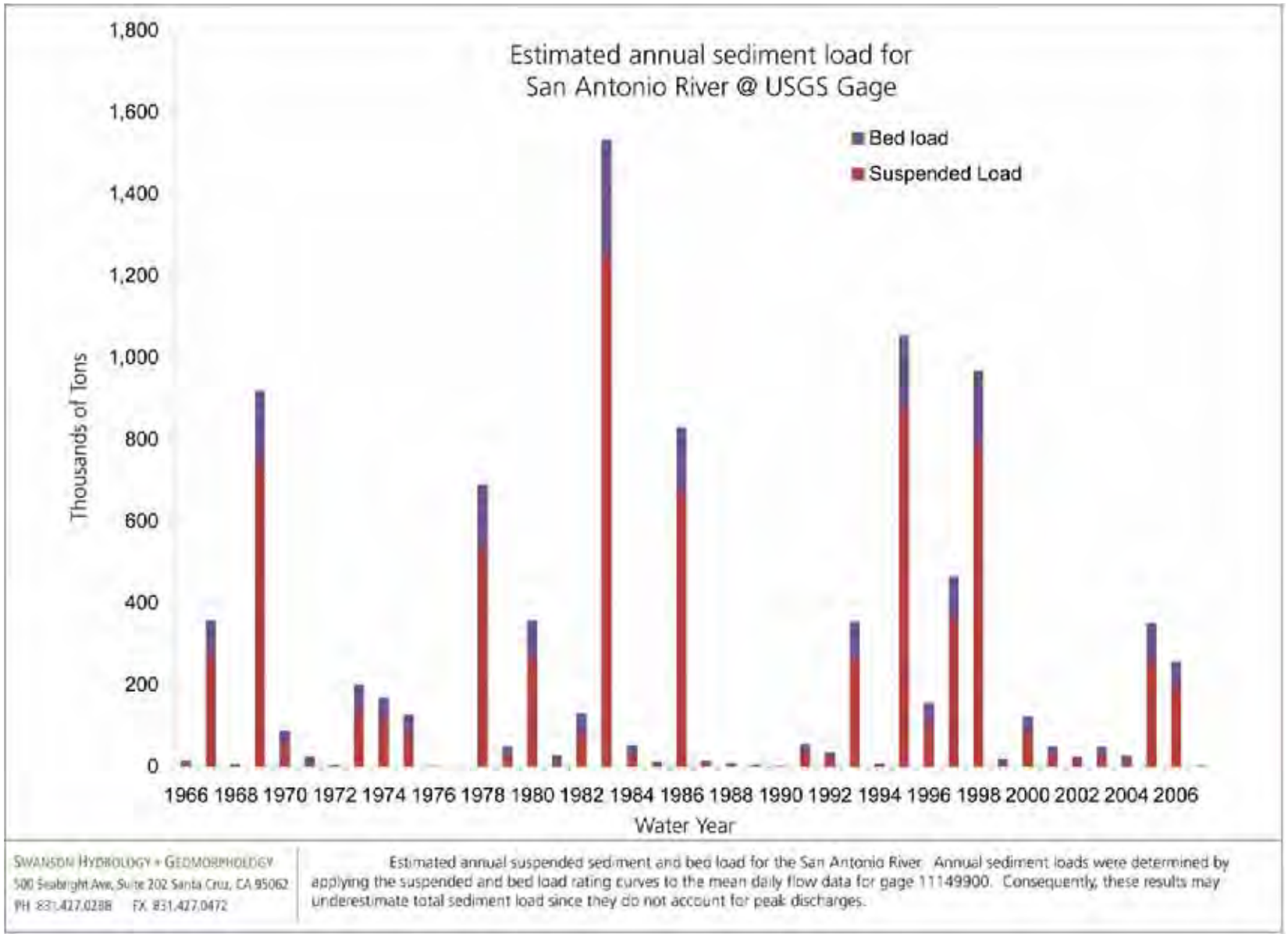


Figure 28. Estimated Annual Sediment Load for Nacimiento and San Antonio Rivers

F. Demographics

The primary population centers in the watersheds are Heritage Ranch and Oak Shores, Lockwood and the military installations. Prior to the creation of Nacimiento Reservoir, the population of the planning area was widely dispersed, with most residing and employed on farms and ranches. However, a special census in 1976 indicated that less than 1% of household heads in the Nacimiento Planning Area were employed in agriculture. The permanent population of the planning area was 271 in 1976, while housing units totaled 632 (based on pre-1990 planning area boundaries). Though future residential development is anticipated to continue to be oriented primarily toward second homes, a modest continuing increase is expected in permanent residents; primarily the retired. Use of homes in the area for leisure activity is reflected in the 80% residential vacancy rate during the winter months (Nacimiento Area Plan, 2003). However, this demographic is likely outdated given that it was originally cited in the 1973 version of the Nacimiento Area Plan. The Steering Committee has elected to collect updated information via the Heritage Ranch and Oak Shores Homeowner's Association as well as CSD water delivery records.

San Antonio River Watershed

The population of South County has increased significantly since 1960, when the population was only 1,702. The population had grown to 2,989 by 1970, an increase of 75.6%. In 1980 the number of South County residents was 3,597, an increase of 20.3% in ten years. The Planning Area's 20% increase in population ranks seventh among Monterey County's eight planning areas (South County Area Plan of the Monterey County General Plan, 1987 with updates). The Nacitone Watersheds comprise 33% of the South County Planning Area. This planning area includes the communities of Lockwood, Bradley, Parkfield and San Ardo; although only Lockwood is located inside the Nacitone area.

Population Change, 1960 – 1980

Location	1960 Population	1970 Population	% Change 1960-1970	1980 Population	% Change 1970-1980
South County Planning Area	1,702	2,989	75.6	3,597	20.3
Monterey County	198,351	247,450	24.8	290,444	17.4

Sources: 1960, 1970 and 1980 U.S. Census of Population

Figure 28a. 20-Year Population Changes

South County is the largest planning area in Monterey County and has the lowest population density – 2.8 persons per square mile in 1980, compared with 87 persons per square mile countywide. It should be noted that 68% of the South County Planning Area is devoted to agriculture and 28% of the Planning Area is under public land ownership. Thus, the density throughout South County is not uniform. South County's ethnic composition is very close to that countywide. South County has a slightly higher proportion of Caucasians and persons of Spanish origin and a lower proportion of Asians. South County has a higher percentage of teens and young adults between 15 and 24 years of age and a lower percentage of children, adults, and elderly. The age structure reflects the presence of Fort Hunter Liggett, where 60% of the population is between the ages of 18 and 24. Without Fort Hunter Liggett, South County's age composition is very close to that of the County. The South County Planning area encompasses almost 40% of the area of the entire county.

TABLE A POPULATION PROJECTIONS NACIMIENTO PLANNING AREA		
Year	Population of Planning Area	Percentage of Total County Population
1989	1,918	.90
1990	2,076	.93
1995	2,618	1.00
2000	3,186	1.07

Source: Nacimiento Area Plan (2003)

Figure 29. Population Projections for the Nacimiento Planning Area 1989-2000

Figure 29 (Table A) contains population projections for the Nacimiento Planning Area. Due to the small number of people and the seasonal nature of the population, individual population projections were not included in the 2003 update of the Nacimiento Area Plan for either the Oak Shores or Heritage Village areas. For comparison, Figure 30 Table B contains the projected population absorption capacity which is the potential planning area population resulting from unconstrained growth and fully-occupied development to the maximum permitted in each land use category.

It is not possible to accurately project future population growth for the Nacimiento Planning Area because of its small population and the seasonal or recreational nature of the population. Future growth in the area is based primarily on migration, which bears little relationship to current local economic conditions. Figure 33 contains population projections based on 4%, 8% and 10% annual growth rates. The 4% projection is a simple extrapolation of the 1970-1979 average growth rates. This is nearly double the total growth projection of 2% for the entire county between 1980 and 1985. The 10% growth rate is a high figure based on sustained growth patterns similar to the late 1979's. The absorption capacity figures in Table B are estimates based on permanent occupancy of the residential units in the planning area. However, since the planning area is also a major recreational attraction, the absorption capacity could be increased by as many as 30,000 under peak weekend conditions (estimate from previous Lake Nacimiento-San Antonio General Plan). This could result in as many as 55,000 to 60,000 people being in the planning area under maximum peak conditions.

TABLE B ABSORBTION CAPACITY NACIMIENTO PLANNING AREA				
Land Use Categories	Rural Area	Heritage Village	Oak Shores	Total
Agriculture	1,036	-	-	1,036
Rural Lands	900		-	900
Residential Rural	1,087	705	-	1,792
Residential Suburban	-	-	-	
Residential Single Family	-	16,477	5,810	22,287
Residential Multi Family	-	11,213	576	11,798
ABSORPTION CAPACITY	3,023	28,395	6,386	37,813
Existing Population 1989	*	*	*	1,918
POTENTIAL ADDED POPULATION	-	-	-	35,895

Source: Nacimiento Area Plan, (2003)

Figure 30. Absorption Capacity of the Nacimiento Planning Area

	1990	2005	New Units	% increase	Average Annual % increase
Heritage Ranch	1047	1425	378	36.10	2.08
Rural Nacimiento	761	861	100	13.14	0.83

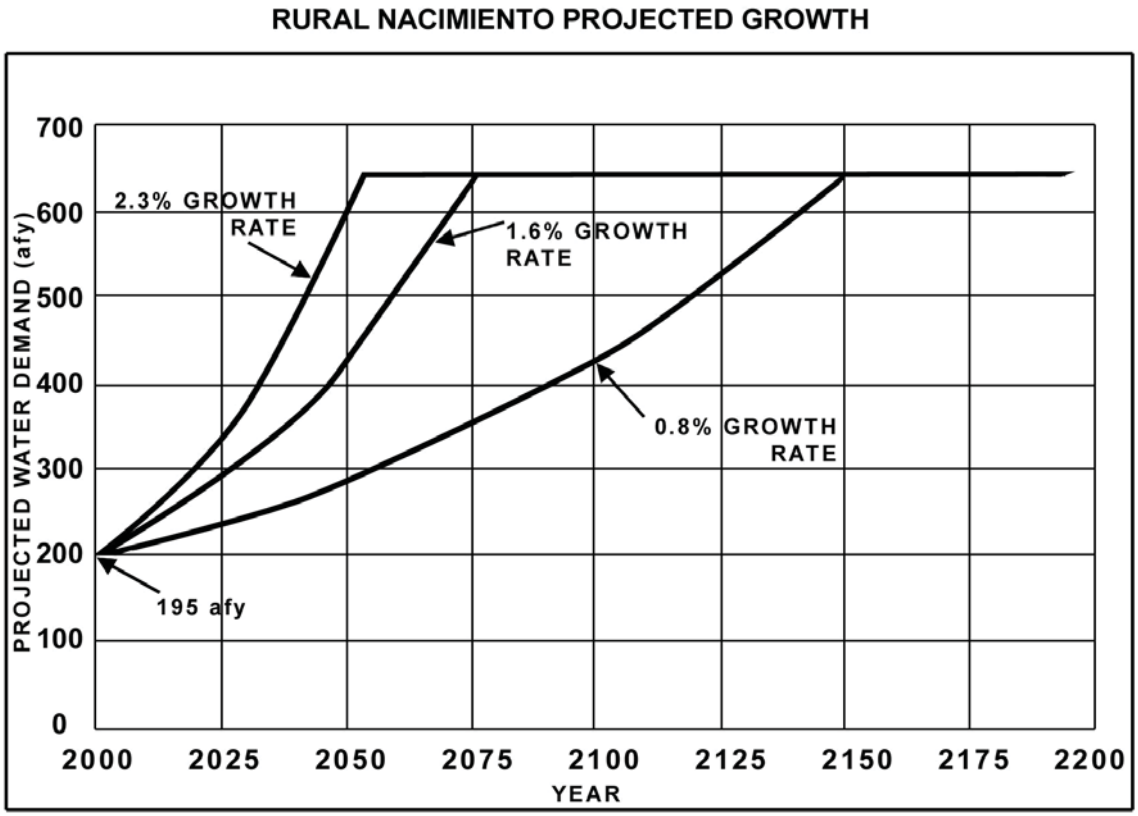
Source: Annual Resource Summary Report, SLO County, 2006

Figure 31. Dwelling units in Nacimiento Planning Area

Population in households							
Year	2000	2005	2010	2015	2020	2025	2030
Nacimiento Planning area	2778	3147	3357	3563	3782	4015	4261

Source: 2005 Urban Water Management Plan Central Coast Water Authority

Figure 32. Projection of population in households within Nacimiento Planning Area



Source: Nacimiento Lake Lakeside User Set Aside, 2004

Figure 33. Projected Growth for Rural Nacimiento 2000-2200

Oak Shores Population

The current County Service Area 7A (CSA-7) includes the community of Oak Shores which is located on the north shore of Nacimiento Reservoir within the Nacimiento Planning Area. The County Land Use Element, the Nacimiento Area Plan, and the standards in Chapter 22.102 serve as the specific plan for the development of Oak Shores. The 1974 Oak Shores Specific Plan originally provided for 4,000 units for the entire community. Since then, the Land Use Element has significantly reduced anticipated land uses. The reductions in development potential are primarily adjustments in the village boundary to exclude northern portions of the Lynch

Flat area. The resultant maximum allowable number of dwelling units within the Oak Shores village reserve line is 1,786, including RV sites. The village is 1,576 acres in area. Just to the north of the village reserve line is the Tierra Redonda Mountain sensitive resource area (SRA) which encompasses approximately 1,300 acres with 320 acres under Bureau of Land Management ownership. Oak Shores has been envisioned as a resort community of vacation and retirement homes with various recreational uses (Oak Shores EIR, 2007).

Development Entity	Number of Units	Cumulative Units
Existing CSA-7A Dwellings*	583	583
Future CSA-7A Dwellings	269	852
Davis/King Tract 2162 Phase 1	60	912
Davis/King Tract 2162 Phase 2-6	285	1197
Bean/Lynch Canyon Properties (Hughes) Tract 2520	307	1504
Munari	134	1638
Vaughn/Taylor/Crawford	25	1663
Lynch Canyon Properties (Hughes)	50	1713

* *taken from Gering Taylor & Assoc. as of 2005*

Source: Oak Shores EIR, 2007

Figure 34. Proposed Oak Shores Development

Both Watersheds

The following visitor numbers do not reflect people entering the reservoirs through private communities.

Visitor Numbers for San Antonio Reservoir

Based on County attendance data for San Antonio Reservoir, the following counties account for nearly 70% of the visitation to the reservoir: Monterey, San Luis Obispo, San Benito, and Santa Barbara Counties. The population of the market area as of 2006 was 1.1 million people. Total annual visitation is estimated to be about 380,000 persons (visitor days) (RFI #11047 Concessionaire Lake San Antonio and Lake Nacimiento, 2007).

Visitor Numbers for North Shore San Antonio

Peak visitor months on the reservoir are June, July and August with visitor numbers for 2006/2007 ranging from a high on July 4th of around 100,000 to a low of 35,000 at the beginning and end of the summer season. Peak visitor days are July 4th, Labor Day and Memorial Day with July 4th and Memorial Day often having 100,000 to 140,000 visitors. Over the course of the last three years visitor attendance has increased with the year 2006/2007 seeing a total of approximately 2,708,000 visitors.

Visitor Numbers for Nacimiento Reservoir

Based on records of the most recent lessee, Lake Nacimiento Resorts, annual attendance at Nacimiento Reservoir was estimated at approximately 180,000 persons. The market area for the reservoir that accounts for about 70% of visitation includes the trade area for San Antonio Reservoir and the counties of Fresno, Kings, Tulare, Kern, Los Angeles (may account for approximately 30%) and Ventura.

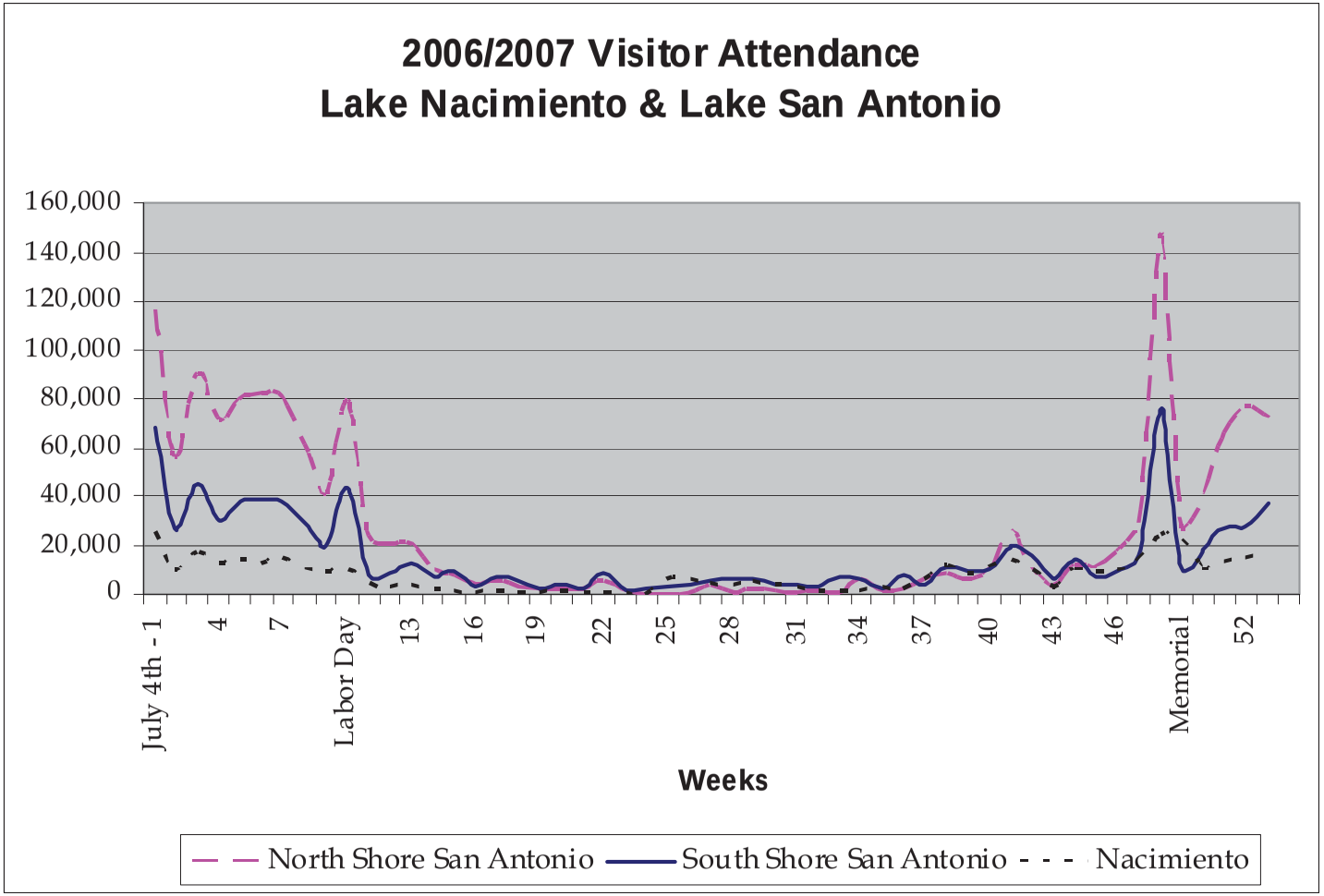


Figure 35. 2006/2007 Visitor Attendance to Nacimiento and San Antonio Reservoirs

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PART 3
Watershed Strategy

A. From Issues to Recommendations:

The issue statements developed by the Steering Committee emerged over a series of discussions and activities progressing from one-word statements of a concern to complex, underlying issues and ultimately into reasoned statements of the core issues as they relate to these watersheds. These issue statements in turn enabled the Steering Committee to set goals, objectives and implementation measures that reflect upon the issues. The issues are not presented in priority order.

ISSUE 1 – Recreation
ISSUE 2 – Gaps in Knowledge: Monitoring and Information Needs
ISSUE 3 – Preventing Pollution from Point and Nonpoint Sources
ISSUE 4 – The Role of Agriculture
ISSUE 5 – Fire in the Watersheds
ISSUE 6 – Taking Enforcement Action
ISSUE 7 – Communication & Coordination
ISSUE 8 – Watershed Health: Plants & Animals
ISSUE 9 – Roads and Culverts
ISSUE 10 – Education and Outreach Needs
ISSUE 11 – Invasive Species

As Steering Committee members learned more about their watersheds and read through the inventory of source documents compiled into the Watershed Resources Inventory (WRI) they began to realize that there are few documented water quality problems in these watersheds. Some Steering Committee members think that recommendations need to be based upon data documenting existing problems in these watersheds. Others think that problems may exist that have not been documented and that potential problems should be addressed in the recommendations of this Plan.

This discussion led to an agreement that baseline information is needed to improve our ability to understand current water quality and prevent problems.

Recommendations (implementations) you will find in this part of the Nacitone Watersheds Management Plan are designed to protect water quality and watershed uses by:

A. Sharing and coordinating the use of existing information

B. Engaging watershed residents, project proponents, private contractors, environmental groups, appropriate agencies, and others to learn about and protect watershed uses on a voluntary basis and in light of existing laws.

C. Gathering, sharing, and coordinating additional information and set water quality baselines to track change over time where possible.

An over-arching recommendation of the Plan is to seek funding for and contract with a watershed coordinator/grant writer who would develop grant proposals to conduct some of the implementations in the Plan and act as staff for the Nacitone Steering Commmittee.

IMPORTANT NOTE:

The remainder of this Chapter is broken into ISSUES each starting with a statement. The issue statements are not all science-based but were identified and described by stakeholders and refined by the Steering Committee. The issue statements reflect the opinions of watershed users and are a result of multiple community meetings, Steering Committee discussions, and learning about the watersheds.

The basis of all issue statements is the use of sound reasoning to promote voluntary protection of water quality and watershed uses in accordance with the Vision Statement adopted by the Steering Committee.

For each ISSUE, background information is provided under STATUS AND REFERENCES where there are references to the *Watershed Resources Inventory* and the *Analysis and Appendices.* These documents can be found at www.Nacitonewater.org website or upon request. *Goals, Objectives, and Implementations* are then described for each ISSUE.

Many of the recommendations (implementations) in this chapter are meant to provide support for future potential funding should a group or entity desire to carry out the recommendation. There is no intention to create additional costs for watershed residents or others. Potential partners for implementations are suggestions only and intended to supply ideas for future groups to consider in carrying out recommendations.

The implementation recommendations will need to be tracked and updated, beyond the timeframe of developing the Final Plan (October 2008), as new information is made available. There may be success stories to tell and lessons learned from attempting some of these implementation measures. There may also be new measures recommended or reasons for a shift in the order of priorities. A table of the recommendation and indicators of progress toward fulfilling the recommendations is included in Appendix I.

B. Prioritizing Recommendations

The ranking criteria below were used by the Steering Committee and Technical Advisory Committee to prioritize recommended implementation actions.

Ranking criteria are designed to address recommendations that are not science-based but reflect a community observation or concern. The word "project" used below is for simplicity although many of our recommendations are not actual, on-the-ground projects. This list is not in any specific order.

1. Cost / Benefit Analysis: projects that are the least costly way to provide benefits are preferred under this criterion.

2. Types of Benefits: projects that provide these benefits are preferred under this criterion.

- Direct water quality benefit: (directly reduces the amount of a pollutant entering waterways)
- Community economic benefit: (protects property values, protects livelihood within the watershed,
- Social capital benefit: (Builds trust, Develops partnerships, Improves communication/coordination, Engages and educates watershed users)
- Environmental / Watershed function benefit: (erosion control, fire prevention/ management, flood control, water quality protection / improvement)

3. Long-lasting Benefits: projects with the ability to protect and ensure benefits over a long term are preferred under this criterion.

4. Likelihood of Success: projects that have less risk or uncertainty (i.e.: political, technical) are preferred under this criterion.
This criterion considers factors affecting the likely success of a project.
Among the criteria to consider is the ability to monitor and evaluate any proposed project's success as well as the ability to correct problems that arise during implementation and the qualifications of companies or individuals expected to implement the project. Also under this criterion could be readiness timing, landowner willingness, access and engineering.

5. Technical or Scientific basis: projects based on solid, scientific evidence are preferred under this criterion. This criterion assesses the type of information upon which the project proposal is based. **(NOTE: scientific evidence can include 1) studies conducted in other places which provide lessons learned, mistakes, successes, and 2) measures or "indicators" other than water quality data.)**

6. Addressing Watershed Issues: projects that address an identified watershed issue are preferred under this criterion.
As the critical issues have not been ranked in terms of priority in the plan, this criterion must consider the extent to which an implementation measure or project resolves or addresses the issue.

7. Strengthens existing efforts: projects linked to existing efforts in a positive way, giving them strength and potentially a higher likelihood of success is preferred under this criterion.

8. Knowledge gap: projects that will fill an identified gap in knowledge for these watersheds are preferred under this criterion.

9. Opportunities for cost sharing: projects for which there are good opportunities for partnerships across entities that could leverage the resources needed and/or to solicit funds (grant writing etc.) to conduct the project.

Prioritization of Plan implementations (recommended actions)

Top priorities that emerged from the stakeholder process :	
Short term (1-2 years)	**Long term (5-10 years)**
Continue the Nacitone Watersheds Steering Committee by seeking funding and contracting with a watershed coordinator/grant writer.	
Support the development and maintenance of Round Tables with an Inter-county Task Force on land use and water resources planning as the top priority Round Table (Issue 7)	
Monterey County, San Luis Obispo County and resident associations should work together to develop and implement programs to control invasive species. (Issue 11, Implementations 1C)	
Water quality monitoring, interpretation, and coordination across multiple entities. Continue existing water quality monitoring. In addition, establish a comprehensive water quality monitoring program with uniform collection, analysis and reporting protocols across pertinent jurisdictions for technical and public sector use. As part of this information gathering, encourage EPA to conduct a lake bottom sediment study of Nacimiento reservoir to better understand mercury contamination.	Support for SLO County to eliminate the risk to water quality of the Oak Shores Interceptor line at Nacimiento reservoir.
Support the work of existing Local Fire Safe Councils (Issue 5, Implementation 1B)	
Conduct road system survey to prioritize needs for erosion control. Include a focused survey on the Tank Road in coordination with military, etc. (Issue 9, Implementations 1B and 2B)	Implement proposed upgrades to the Tank Road and others within these watersheds in coordination with others. (Issue 9, Implementation 2B)
Collaborate on the design and implementation of educational stewardship campaigns targeting watershed residents and visitors with customized messages such as “Be A Watershed Citizen.”	

C. Watershed Issues, Goals and recommendations

ISSUE 1 – Recreation

ISSUE:

As a land use, recreation has, for many years, been an important factor in the watersheds. Recreation contributes to property values, community economics, and allows residents, as well as thousands of visitors each year, to enjoy the varied beauty of the watersheds. Nacimiento and San Antonio Reservoirs offer a variety of water activities including boating, swimming, fishing, waterskiing, and wakeboarding. In addition, the Los Padres National Forest and Fort Hunter Liggett within the watershed provide camping, hiking, swimming, hunting, fishing, equestrian, and wilderness experiences. These areas of the watersheds also provide for interpretation and study of archeological and historic sites, nature study and enjoyment, and artistic and esthetic appreciation of a natural landscape. Unfortunately, recreation also presents the opportunity for harm to the watershed due to trash, vandalism, point and nonpoint pollution, damage to public and private property, crime and other inhibitors to water quality. The continuation of recreational opportunities and the community economic benefits they provide is a high priority for these watersheds while preventing any negative impacts from those activities.

STATUS and REFERENCES:

Much of the recreation in these watersheds occurs in the mid-watershed area in and around the two reservoirs. Many people have purchased property around the reservoirs because of the recreational uses available and rely on those uses to maintain their property values. The following is excerpted from the Salinas Valley Water Project EIR to provide insight into the economic benefit derived thereof.

> *The Monterey County Department of Parks quantifies and tracks use of the reservoir through "units." A unit constitutes any of the following: 1 camping fee, 1 day use fee for a vehicle or boat, yearly boat permits, or a set dollar amount of concession intakes. Units are different than visitor-days, but it can be assumed that an increase in units is equivalent to an increase in visitation, and vice versa. Although there appears to be a general relationship between lake levels and the number of units bought, historical data shows that there is not always a direct correlation. For example, Table 5.9-2 shows that in 1987 the average surface elevation at Nacimiento was 754 feet with 28,137 units bought. In 1992 the average elevation was substantially lower (696 feet) and more units were purchased (30,538). Still, there is a general trend that suggests visitation increases as lake levels increase.*
>
> *An average of 23,452 units per year is sold at Nacimiento, based on years 1985 through 1994. The range in annual units sold for this period was between 9,885 in 1989 and 32,896 in 1993. At San Antonio Reservoir during the same period of time, 99,660 units were sold on average per year, with very large fluctuations. The annual high and low sales points during this period were 25,983 units in 1990 and 185,751 units in 1987 (the north shore of San Antonio Reservoir was closed 6 months in 1990, all of 1991, and for 6 months in 1992, which likely affected units purchased). Table 5.9-4 shows combined number of units sold for the two reservoirs. As described above and shown in Tables 5.9-2 and 5.9-3* [tables are within SVWP EIR]*, although there appears to be some correlation between unit sales and lake levels, this relationship is not linear and only reflects a general relationship. There may be many factors influencing recreational use, including among other things, facilities availability, weather conditions, and trends in rainfall over a several year period, etc.*

An increase in year-round and visitor populations around both reservoirs and the surrounding areas may have increased recreational pressures in the watersheds. The infrastructure of the watersheds, specifically during the periods of heavy recreational use, may not have kept up with the increase in population. Additionally, increased usage and development may impact the rural character of the watershed. Prevention of negative impacts from recreational uses is a high priority for these watersheds. The large numbers of people during the height of summer can, and often does, result in an increase of illegal activity including pollution of reservoirs, trespass on private property, vandalism and theft.

Specific concerns for water quality related to recreational use include: a wide variety of trash and debris in the reservoir and inlets, increased use of toilet facilities, vandalizing of toilet facilities, improper disposal of camper waste, unsafe boat speeds exacerbating erosion along the shoreline, petroleum leaks from boat engines, overcrowding of Nacimiento Resort parking areas at the 'Point' and launch ramp marina, and vandalizing of boat docks. While there is little data available, there are concerns that aging or inadequate onsite wastewater systems could contribute negatively to water quality. Nutrient loading which can lead to algal blooms and pathogen loading has serious impacts on water quality. There is significant documentation of these impacts from other watersheds. While there is insufficient water quality data for these watersheds, it will be important to assess and document the extent to which there are existing water quality problems or potential problems that can be prevented, These types of pollutants can make water unsuitable for recreational and other watershed uses. All of these concerns and others as well, are greatly exacerbated when recreational use is heavy.

Hiking, camping, hunting, fishing, equestrian, and other wilderness experiences within the Los Padres National Forest, Fort Hunter Liggett and the Ventana Wilderness Area can be impacted due to problems such as trash, trespassing, vandalism, improper disposal of camper waste, erosion from unclassified/unauthorized (non-system) roads utilized for camping/hiking, intentional and un-intentional damage to archaeological resources, etc.

GOAL: Ensure the continuation of the economic benefits and attractive and enjoyable recreational experiences available to residents and visitors with a focus on water quality and watershed protection.

OBJECTIVE 1: Focus recreational uses in existing public areas where there is supportive infrastructure. Reduce/eliminate trespass on private property within the watersheds.

Implementation 1A: Support the use of passive and active deterrents to trespass on private property as well as public property not designed for public use. Passive deterrents should include but not be limited to: signs, education and outreach. Active deterrents should include but not be limited to: fencing and log booms where these would effectively protect the public resource.

Implementation 1B: Support the efforts of Monterey County Parks Dept., the Monterey County Water Resources Agency, and the Sheriff's Departments in both counties in efforts to deter and punish illegal activities that affect watershed health.

OBJECTIVE 2: Minimize soil disturbance and threats of erosion (campgrounds, parking lots, boat ramp areas, non-system roads etc.) in public areas and on public lands.

Implementation 2A: Provide informational signs and support efforts of recreational clubs to inform the public of erosion problems, their related impacts and erosion prevention measures.

Implementation 2B: During the summer season (May through September), minimize soil disturbance from vehicles in unpaved areas by posting signs, patrolling, and providing information to visitors about erosion and water quality.

Implementation 2C: During the off-season (October through April) restrict vehicle access in unpaved areas by posting signs and patrolling the area. (Possible Sign Examples: "Access to marina only", "No overnight camping")

Implementation 2D: Ensure that future, or expanded, recreational areas are carefully planned to protect watershed resources (water quality, habitat, etc.)

OBJECTIVE 3: Promote protection of water quality and respect for the watersheds by visitors and residents in recreational areas. Examples include but are not limited to: reducing incidents of parking in un-marked areas, littering, camping in non-camping areas, and improperly disposing of waste.

Implementation 3A: Work with multiple community groups and agencies to promote campaigns that are customized to the target audience such as: "Be a Watershed Citizen", "Welcome to our Watershed", "Party On: Keep Your Lake Clean", "Keep Nacimiento/San Antonio Blue" and others.

Implementation 3B: Encourage enforcement of existing ordinances prohibiting overnight camping on land not designated for overnight camping by the appropriate county's Sheriff's Department or Monterey County Parks Rangers.

Implementation 3C: Encourage SLO and Monterey counties to review existing ordinances and to adopt severe fines for littering, dumping, or polluting in the watersheds. These ordinances would need to be enforced by the appropriate entity for either land or water activities.

Implementation 3D: Encourage Monterey County Water Resources Agency and Monterey County Parks Department to provide an increased number of parking, restroom, and trash facilities at strategic public recreation sites. Homeowners associations should be encouraged to provide additional facilities for their own, private users. New or improved parking areas should be designed as permeable surfaces to minimize runoff potential.

Implementation 3E: Promote a campaign to report vandalism of restroom facilities, boat docks, and other private or public facilities.

Implementation 3F: Consider raising funds to support the development of a comprehensive recreational guidebook and map of both watersheds that includes a foldout map with details of recreational activities and facilities that exist within the reservoir area and that exist outside of the reservoir areas, and lists rules and regulations in place to protect the natural resources for current and future use. Utilize existing guidebooks to ensure this product is unique and valuable.
Implementation 3G: Work with County Parks on the possibility of posting "Lake Watch" signs at boat docks and floating toilets in a "Neighborhood Watch" attempt to deter negative behavior.

Implementation 3H: Encourage the US Forest Service to promote dispersed car camping in already impacted areas rather than creating new camp-sites in pristine areas of the Los Padres National Forest.

Figure 36. Recreation at the San Antonio Reservoir
(Source: Monterey County Parks, 2007)

ISSUE 2 – Gaps In Knowledge: Monitoring & Information Needs

ISSUE:

Protecting the water quality of these streams and reservoirs is a high priority for all watershed uses. However, there are few documented water quality problems in these watersheds. This may mean there are not water quality problem or that we are currently not aware of existing problems or potential problems. Establishing a baseline of water quality from which to track change over time is a priority for these watersheds.

STATUS and REFERENCES:

Water quality concerns of the Regional Water Quality Control Board for these watersheds are:

Nacimiento reservoir – Mercury in fish tissue;
Las Tablas Creek – Excessive mercury, sedimentation, total dissolved solids (TDS), electrical conductivity (EC), sulfate, and nickel.

A Total Maximum Daily Load (TMDL) clean up plan was developed by the Regional Water Quality Control Board for mercury from mine runoff in Las Tablas Creek (which drains into the Nacimiento Reservoir). In addition, the U.S. Environmental Protection Agency (USEPA) has listed the mines on the National Priority List of Superfund Sites which triggered Federal clean up measures superseding the TMDL. The Klau/Buena Vista mines are non-operational and are considered to be significant sources of mercury entering downstream waterways.

Below is a brief summary of water quality findings that are more thoroughly described in the **Existing Conditions** section of this Plan. Most of the statements below are based on very little data and do not signify water quality problems. Rather, they are areas to consider in the establishment of baseline monitoring data. Establishing baseline conditions of local water quality may be important to maintaining good water quality over time.

Information Source	San Antonio River Watershed :
Camp Roberts INRMP, 2000	Camp Roberts found total dissolved solids (TDS) and selenium **at levels that occur naturally in the river**.
LOW	Monterey County Water Resources Agency found nitrate levels in the reservoir that are **below the maximum allowable for drinking water**.
Jenks and Adamson, 1970	Monterey County Parks has had reservoir samples with **high levels** of manganese.
Camp Roberts INRMP, 2000	Camp Roberts' monitoring found a **potential problem** with cadmium in the San Antonio river.
Logan, 1987	Monterey County Flood Control and Water Conservation District found **high level** of nitrates in a Lockwood well
	Nacimiento River Watershed:
Heritage Ranch Sanitary Survey Update, 2005	The source water for the Heritage Ranch CSD wells is the Nacimiento River. The water quality in these wells, located in the Nacimiento River one mile downstream of the dam, **meets primary drinking water standards** and except for occasional detection of high iron and manganese levels also **meets secondary drinking water standards**.
Appendix E **of WRI Analysis**: Report by SLO County Public Works, Water Quality lab report summarizing history and results of the Nacimiento Water Project (NWP) water quality monitoring program	San Luis Obispo County Public Works Department has collected some data at the intake location for the Nacimiento Water Project. Results vary, and can be a function of different factors. Most notable are **high values** found for total coliforms, algae, turbidity, aluminum, iron, and manganese. The monitoring program was initially designed to provide information for water treatment plant design, and will be revised to meet ongoing operational needs. Concerns for ongoing operations include invasive species, runoff, pathogen loading, nutrient loading, carbon loading, suspended solids and metals deriving from various watershed uses, to name a few.
Regional Water Quality Control Board, WMI, 2002	Nacimiento Reservoir is **listed as impaired** for mercury in fish tissue
	Las Tablas Creek: (in the mid 1990's)
Salinas Valley Water Project, EIR, 1998	Low nitrate levels
Salinas Valley Water Project, EIR, 1998	High aluminum and iron levels

These sources are found in the WRI and WRI Analysis, Nacitone 2008.

Figure 37. Possible Water Quality Concerns

It will be important to determine the best way to assess and document the extent to which these are existing water quality problems or potential problems that can be prevented. For example, one water quality concern voiced often by several Steering Committee members is that of trash in streams, creeks, and reservoirs. Although there is anecdotal information from watershed residents, there are no data available to consider this issue. It may be possible to detect such a problem by establishing an indicator or monitoring for toxins created by degrading plastic, metals, or volatile organic compounds that might be residuals from trash and debris.

GOAL: Maintain and protect the quality of surface water and groundwater found in these watersheds.

OBJECTIVE 1: Establish baseline water quality data of relevant constituents for water bodies in these watersheds to ensure water quality is protected, that early detection to prevent problems is possible, and to track changes in water quality over time.

Implementation 1A: Continue to compile a list of other entities conducting water quality and invasive species monitoring in these watersheds and determine: constituents monitored, frequency, locations, and purpose of the monitoring.

Implementation 1B: Support the coordination of water quality monitoring and interpretation in these watersheds through use of mechanisms such as compatible Quality Assurance Project Plans (QAPP), database formats, and facilitation of roundtable discussions to understand the data.

Implementation 1C: Encourage responsible agencies to work together to provide funding for establishing a comprehensive monitoring program that will provide data to all agencies, and eliminate redundancies. This data could then be used to identify problems and recommend corrective actions.

Implementation 1D: Partner with the water purveyors, Resource Conservation Districts, Natural Resources Conservation Service, Cal Poly, and others to monitor the effectiveness of voluntary management practices for protecting water quality; ensure that data is kept confidential and summaries of the information do not identify any landowner.

Implementation 1E: Support the initiation of a volunteer water quality monitoring program including monitoring at the confluences of creek to main stem and creeks to reservoirs.

Implementation 1F: Encourage EPA to conduct a reservoir bottom sediment study of Nacimiento Reservoir to better understand mercury contamination.

OBJECTIVE 2: Identify potential contaminant sources, magnitude of threat to water quality, possible preventive or mitigation measures, and gaps in knowledge**.**

Implementation 2A: Develop a thorough, comprehensive, quantitative as well as qualitative, description of all current and projected watershed uses that can harm water quality. Evaluate these uses for potential to degrade water quality. Identify remaining gaps in knowledge and develop mechanisms to address these.

Implementation 2B: Working with watershed users, identify possible preventive or mitigation measures for problems or potential problems identified in the study described above.

Implementation 2C: Collaborate with entities required to conduct sanitary surveys including SLO County Public Works Department Water Quality Lab, and Heritage Ranch Community Service District.

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ISSUE 3 – Preventing Pollution from Point and Nonpoint Sources

ISSUE:

Making all watershed users aware of point and nonpoint sources of pollution and how to recognize and prevent them is a high priority for these watersheds.

STATUS and REFERENCES:

Point and nonpoint source pollution negatively affect water quality measured by the ability of the water body to support state designated beneficial uses. See a detailed discussion of beneficial uses in the **Existing Conditions** section of this Plan.

Point source pollution results when water conveys pollutants into a waterway from a discrete, potentially identifiable source. Point sources such as domestic wastewater and commercial / industrial waste discharges can be identified and controlled and are regulated with discharge permits. Existing point sources in these watersheds are allowed to discharge regulated amounts of: wastewater, solid waste, and processed water. There is a complete list of point sources permitted to discharge in these watersheds in the **Existing Conditions** section of this Plan.

Nonpoint sources of pollution are difficult to see, measure, or regulate. They result when water (including stormwater and non-stormwater) moves across the landscape and picks up pollutants such as nutrients, sediment, chemicals, oil and grease, bacteria, etc. and conveys them into water bodies (rivers, streams, reservoirs, and groundwater). Nonpoint sources may occur at many different locations spread over a large area and are regulated by waste discharge requirements, conditional waivers in the public interest, or prohibitions (2004 Nonpoint Source Implementation and Enforcement Policy, State Water Resources Control Board; webpage: http://www.waterboards.ca.gov/water_issues/programs/nps/#programs).

Potential nonpoint sources of pollution relevant to land uses in these watersheds:

- **Fertilizers and pesticides from careless application or improper disposal;**
- **Bacteria and nutrients from malfunctioning septic systems; human and animal feces;**
- **Sediment from erosion due to poorly designed or maintained roads and construction sites, streambank, shoreline, and rangeland erosion, abandoned mines, off-road vehicles, recreational trails, burned areas;**
- **Stormwater conveyance of grease, oil, metals, nitrogen/phosphorus-based fire suppression chemicals; nutrients, organic carbon, sediment, chemicals, and trash. Sources of these materials may be legal activities, or they may be from illegal activities such as unpermitted grading, methamphetamine labs and marijuana growing areas.**

It may be possible to determine which of these are causing water quality problems, or pose potential problems that can be prevented. However, an effective watershed-wide approach, emphasizing cooperative solutions, increased education, and development of partnerships, will be more likely to reduce all types of nonpoint source pollution in these watersheds.

Oak Shores Interceptor line:

A specific example of a known, potential source of pollution is the Oak Shores Interceptor line. The sewage collection system for this Nacimiento Reservoir community consists of nearly 10,000 feet of pipeline and several manholes located up to approximately 40 feet below the high water line of the reservoir. Exposed lateral pipelines coming from houses to the interceptor line may be vulnerable to breakage and vandalism. The sewage from residences could then flow into the reservoir. There are also challenges for maintenance and repair staff to gain access to the interceptor line when the line is under water. There is a program in place to ensure that no annexed parcels will be allowed to connect to the Interceptor line. Refer to existing conditions discussion for more examples of potential sources of point and/or nonpoint pollution.

GOAL : Reduce point and nonpoint source pollution in support of designated beneficial uses of local water bodies.

Objective 1: Encourage and provide incentives and information for public and private landowners and homeowners to protect ground and surface water while protecting both property and water rights.

Implementation 1A: Offer homeowner and small business owners water quality protection workshops regularly that detail safe pesticide product use and disposal; septic system maintenance; preventing pollutants from paved and unpaved roads from entering waterways, and generally increase the awareness about the potential impacts of residential areas on surface and groundwater quality.

Implementation 1B: Obtain or develop a flyer and distribute to all watershed residents detailing how we all have a role in protecting water quality and watershed uses.

Implementation 1C: Sponsor educational programs for farmers and ranchers specific to issues in these watersheds at which participants can earn continuing education units. Continue to sponsor Ranch Water Quality short courses.

Implementation 1D: Develop interpretive signage in strategic locations around the watersheds describing how each person has a role in protecting water quality. This could include explaining that Nacimiento Reservoir is a source of raw water that will be treated for drinking water and should be cared for.

Implementation 1E: Educate the public on the watershed and water quality impacts of illegal drug production such as marijuana farming on public lands and meth labs in our communities.

Objective 2: Reduce mercury sedimentation and acid mine drainage in the Nacimiento River watershed**.**

Implementation 2A: Continue to provide community support to US Environmental Protection Agency (EPA) for remediation of the Klau/Buena Vista Superfund Site through participation in the Community Advisory Group and public review and comment throughout the Superfund remediation process. Community support and support from our elected officials is critical to ensure that Congress allocates adequate federal funds to complete the project once the Superfund remediation assessment and design phases are complete.

Implementation 2B: Encourage the MCWRA to request that EPA conduct a comprehensive reservoir bottom sediment study of Nacimiento Reservoir to provide detail to decision makers about future management decisions to include the extent of contamination and the timeframe involved that would reduce mercury level in fish tissue to acceptable levels.

Objective 3: Improve erosion and sediment control for new development and redevelopment in both counties and support the use of Low Impact Development (LID) (integrated management measures that mimic the natural hydrology of the watershed) for stormwater management and road design in urbanized area.

Implementation 3A: Conduct community outreach in the Nacimiento River watershed of San Luis Obispo County to increase awareness about the County's Stormwater Management Programs including informing the public that there will be more frequent, comprehensive grading/stormwater inspections and enhanced enforcement of violations. The new inspection programs, provided for in the revised San Luis Obispo County ordinances, are scheduled to be implemented between 2010 and 2011.

Implementation 3B: Community road associations or other local entities could partner with county departments in the relevant county, Resource Conservation Districts, water purveyors, and other entities to provide annual trainings for private contractors and county maintenance and road crews that would include instruction on the use of management practices that minimize pollutant runoff and erosion damage caused by roads and construction projects.

Implementation 3C: Encourage SLO County Planning and Building through existing regulation to adequately condition new development to ensure infrastructure keeps pace with increased recreational use which may impact shoreline erosion and to determine cumulative impacts of operational launch ramps when water is below High Water Mark.

Implementation 3D: Provide community support for LID methods to reduce the volume and velocity of urban stormwater runoff to downstream lakes and streams by commenting on draft county ordinances as required by the County Stormwater Management Programs.

Goal: Reduce the potential for contamination of the reservoirs by domestic wastewater.

Objective 1: Reduce the potential for sewage leaks from the Oak Shores 'Interceptor line' into the Nacimiento Reservoir.

Implementation 1A: Encourage SLO County (County Service Area 7A) to continue monitoring for leaks and explore other options to fund project which would eliminate this risk to water quality. Institute recommendations #2 through #5 from the 2004 Interceptor Bypass Study.

Implementation 1B: Design and build modified collection system to minimize chance of leakage into the reservoir and to facilitate maintenance and repairs. Ensure that all laterals as well as the collection line are buried and are not vulnerable to vandalism.

Objective 2: Reduce the potential for sewage contamination from public areas to both reservoirs.

Implementation 2A:
Ensure that floating toilets and any other non-plumbed public toilets are routinely pumped and kept clean. Ensure that spills are cleaned up immediately.

Implementation 2B:
Ensure that public, plumbed toilets are properly operating and kept clean. Ensure that spills are cleaned up immediately (Steering Committee requested more detail here).

Implementation 2C: Ensure that public toilet facility capacity matches usage needs.

Objective 3: Reduce the possibility of contamination from septic tanks to both reservoirs.

Implementation 3: Encourage homeowners and residents in these watersheds to do regular septic system maintenance and educate them about "septic safe" practices and cleaning products.

Objective 4: Reduce the possibility of contamination from residential and commercial sewage collection infrastructure to both reservoirs.

Implementation 4A: Ensure that home owners and business owners know who to call for immediate repair of broken, leaking or backed up sewage lines.

Implementation 4B: Ensure that home owners and business owners know who to call if they observe a leaking sewage line that has not been repaired in a timely manner.

Objective 5: Ensure that wastewater treatment facilities operate pursuant to their waste discharge permit.

Implementation 5: Properly design, site, and maintain wastewater treatment facilities and all associated infrastructure.

Figure 38. Impacts of culvert on the Tank Road
(Source: US-LT RCD, 2007)

ISSUE 4 – The Role of Agriculture

ISSUE:

Agriculture in these watersheds is an important contributor to the local economy and is the base of livelihood for many multi-generational families and emerging businesses. Consistent private property rights, and the ability to make decisions internally rather than by an external entity, are what make agricultural endeavors viable in these watersheds. Stewardship of agricultural lands and watershed functions is also crucial to the viability of agricultural operations.

STATUS and REFERENCES:

Agriculture is desired in these communities for many reasons. Farming and ranching operations in these watersheds bring dollars to the local and state economy through the production and marketing of vegetable row crops, fruit and nut orchards, wine and table grapes, cow-calf operations, and contract grazing. These operations also create jobs such as crop care consultants, ranch managers, field foreman and crews, equipment and supply vendors. Beyond these direct, economic benefits, it has been said that, "if you eat food and wear clothes, you are involved in agriculture."

Farming and ranching in these watersheds is also the backbone of property values based upon the rural character and aesthetic views that exist here. More and more Californians and others seek places with a rural feel that are far from urban activity. For many, a move to places like these watersheds symbolizes a personal success in having escaped the hussle and bussle of urban living. Although they come to enjoy this rural paradise, some who move here do not anticipate but discover a vibrant, working landscape of farming and ranching businesses. They discover large, slow-moving farm implements and livestock carriers on roads; wild pig and deer hazards on the roads; dust; noise; and wine tasting and leisure traffic all due to the rural character they sought. This influx of urbanites can cause misunderstandings or accusations about how agriculture impacts the watersheds. There is a need to establish and maintain neighborly communication and information sharing.

Well managed agriculture can provide specific water quality benefits compared to some other land uses. The ground required for raising crops or livestock allows rainwater to saturate the soil keeping organic matter alive, and providing recharge areas to ground water. The soil and vegetation that agriculture requires protects surface water quality by filtering out excess nutrients or other pollutants as water crosses the land. Well managed agricultural operations can do a better job of preventing erosion than some other land uses. In addition, some wildlife species can benefit from agricultural operations and the open spaces provided.

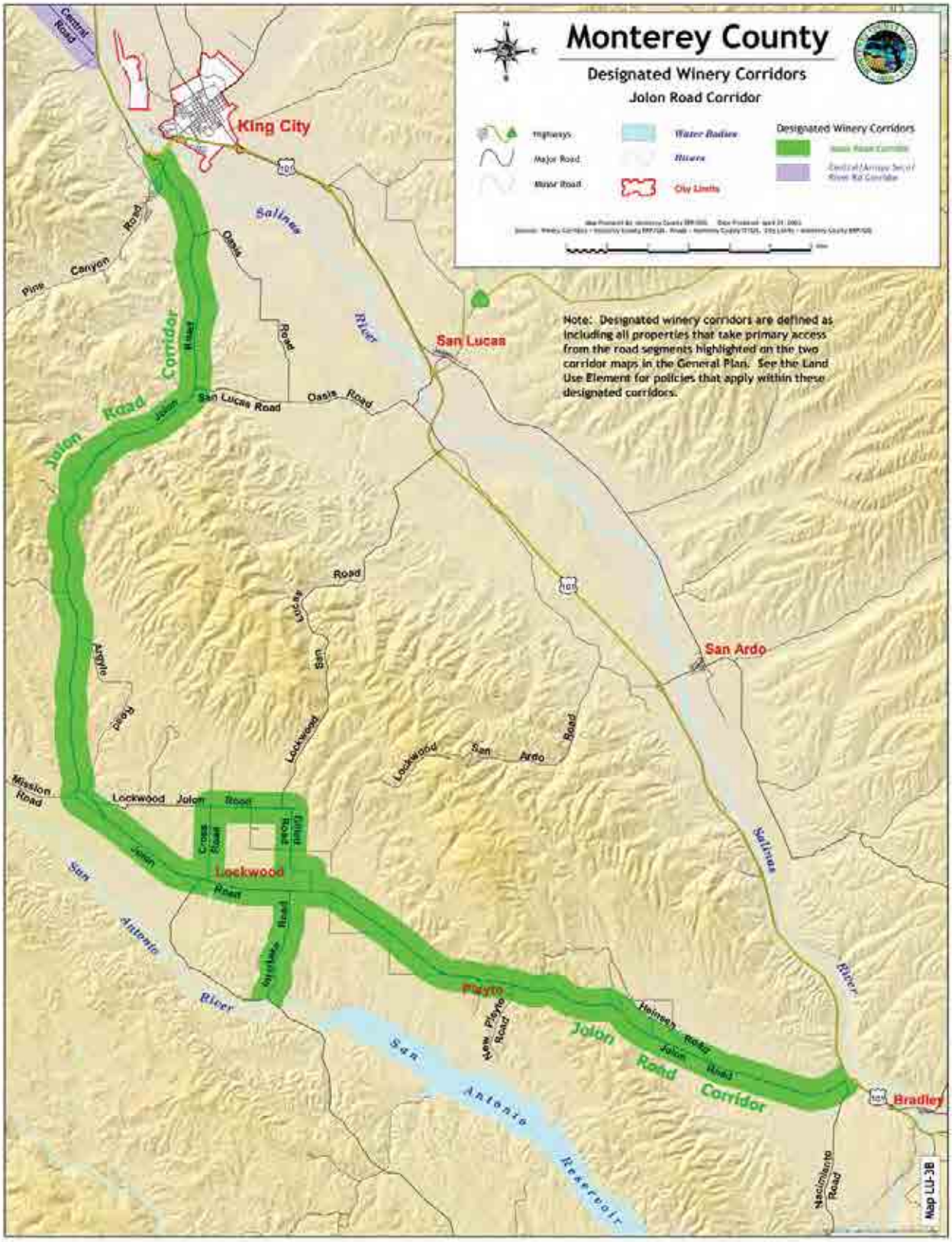

Figure 39. Designated Winery Corridor

GOAL: Ensure that agriculture (farming and ranching) remains a vibrant and economically viable part of these watersheds.

OBJECTIVE 1: Encourage and support the efforts of landowners, farmers, and ranchers to protect soil, water, and air resources critical for keeping agricultural operations a productive part of the economy through the promotion of research, education, and outreach.

Implementation 1A: Monterey County Water Resources Agency (MCWRA) should work with UC Cooperative Extension, Resource Conservation Districts, Farm Bureaus and others to offer the "Ranch Water Quality Short Course" periodically to existing leaseholders on MCWRA land and to other, local rangeland owners / operators. Prepare and distribute DVDs of the November 2007 course conducted in the San Antonio watershed.

Implementation 1B: The Monterey and San Luis Obispo County Farm Bureaus should work with UC Cooperative Extension, Resource Conservation Districts, County departments, water agencies and others to offer water quality protection trainings and workshops to farmers and ranchers in these watersheds on a regular basis. Both implementation 1A and 1B should include bringing in innovative researchers and land managers to share their knowledge and experience with local farmers and ranchers.

Implementation 1C: Encourage watershed specific research through collaborative efforts with private and public landowners to develop strategies to protect natural resources as part of profitable agricultural operations.

Implementation 1D: Assist the Natural Resources Conservation Service (NRCS), Resource Conservation Districts and others with outreach to ensure information on conservation incentive programs through the Farm Bill and other mechanisms are well known to local landowners, farmers, and ranchers.

Implementation 1E: Utilize the Resource Conservation District of Monterey County's Livestock and Lands program to provide educational workshops, materials, and planning assistance for qualified livestock owners in these watersheds.

Implementation 1F: Utilize the general strategies (those not specific to the lands owned by the MCWRA) contained in the Grazing Management Plan as an example for management of grazing in the two watersheds.

Implementation 1G: Create an open dialog about the use of grazing for controlling noxious weeds, improving habitat and improving the health of the grasslands of the Nacitone watersheds.

Objective 2: Educate the public about agricultural operations, its role in the local economy and efforts in environmental protection.

Implementation 2A: Develop an agricultural speaker's bureau through local chambers of commerce, Farm Bureau and farm centers to provide presentations and farm/ranch tours upon request.

Implementation 2B: Encourage local farmers and ranchers to offer their perspective and experience as part of AgKnowledge, an emerging program to educate community leaders about the role agriculture in our communities. The program began in 2007 as part of a joint effort by Monterey County Ag Education and the Grower-Shipper Foundation.

Implementation 2C: Encourage and support local communities to pass to younger generations the importance of protecting watershed uses and watershed resource through schools, farm days and 4H.

Objective 3: Improve coordination and communication among regulatory entities, private, and public entities to manage land and water resources in an effective and environmentally conscious manner.

Implementation 3: Consider creating a Grazing Advisory Committee made up of members of the ranching community, RCD, NRCS and UC Cooperative Extension that would meet periodically to advise public agencies on their grazing programs.

Objective 4: Encourage ranch managers to monitor grazing land on a continuing basis.

Implementation 4A: In order to evaluate effectiveness of management strategies on grazed land, it is recommended that the Residual Dry Matter (RDM) is monitored each fall to ensure that grazing lands and facilities are in good order. Seasonal variations and rainfall should be considered in the RDM evaluation.

Implementation 4B: Encourage ranchers to attend periodic Ranch Water Quality Short Courses.

Implementation 4C: Support private landowners to prepare and implement with assistance from CAL Fire and the local fire districts, an integrated fire plan that addresses the use of managed fires and grazing to accomplish objectives of reducing understory and the potential for hotter, more destructive wildland fires.

ISSUE 5 – Fire in the Watersheds

ISSUE:

The risk of large, unplanned fires in these watersheds is very high due to an abundant fuel load.

> *Far from being the disasters that the media frequently portray them to be, fires in California are essential in maintaining the state's spectacular biodiversity. Not only do fires engender the diversity of California's ecosystems, they directly and indirectly affect the services and products these ecosystems provide to the state's human residents; these include clean water, timber, and recreation opportunities. This is not to say that all fires are beneficial or that they now burn as they did historically. Some fires may be disasters from both an ecological and a social perspective (California Watershed Assessment Manual, 2005).*

The risk to loss of life and property from wildfires has been substantially increased because of the encroachment of residential uses within and adjacent to fire-prone woodlands. Alterations of the period an area burns due to fire suppression and other changes in the natural fire cycle as well as changes in climate on fire behavior are just starting to be understood. Managed burns (often called prescribed burns) and mechanical thinning can be used to safely reduce fuel load and also to manage invasive vegetation. Only Fort Hunter Liggett currently uses prescribed burns in these watersheds as a regular tool. Judicious grazing can also reduce vegetation fuel load. Educating the public, preventing catastrophic wildfires, and safely utilizing fire to conduct land management are priorities for these watersheds.

Fire management is important to preventing negative water quality impacts though not all of these impacts can be avoided. Loss of vegetative ground cover after a fire increases runoff sending eroded soil and nutrients, and other pollutants into the water. Included in this runoff can also be the nitrogen –phosphorus based fire suppression chemicals used by the Cal Fire (also known as the California Department of Forestry and Fire Protection) and other fire agencies. One of the most common of these fire chemicals is Phos-Chek which is dropped as a fire retardant from aircraft.

STATUS and REFERENCES:

There have been several major fires in the upper watersheds since this area was first settled. Significant watershed impacts occur including very large amounts of sediments which caused significant problems. The 1977 Marble cone fire was in part the result of a heavy "sticky snow" which fell in winters just prior to the fire which broke so many trees and large shrubs that fuel load increased by 80%. Similar conditions have occurred in the winter just prior to the 2008 Indians Fire which could have played a large part in the severity of the burn. Most large fires in these watersheds are lightning caused. However, fires may also be caused by people where sufficient fuel load and oxygen are available. Therefore, an educational approach to fire will be the most effective in preventing catastrophic events.

While this plan was being completed, two large fires called the Basin/Indian Complex and the Chalk Fire occurred in June/July 2008 and September/October 2008 respectively. The Indians Fire burned over 30,000 acres (approximately 14% of the entire San Antonio River watershed).

Final numbers for the Chalk Fire were not available before this plan went to press. The portion of the Indians Fire that burned in the San Antonio River watershed occurred in the upper watershed area primarily on the Los Padres National Forest and FHL land. Final Findings of facts and specific recommended treatments of the fire impacts were developed too late in the process to be used in this plan; however, the following is a summary of major initial findings. USFS analysis indicates that the "south side of the Indians Fire contains a large portion of high soil burn severity". More than 75% of the area that burned in the San Antonio watershed was classified as moderate to high severity; compared to the overall proportion of moderate to high severity in the entire Basin/Indians Fire which was approximately 60%. The hot nature of the fire is expected to create significantly increased runoff rates that could result in a doubling of the runoff that would have normally occurred from a storm of the same magnitude. Hazards are expected to be primarily related to flooding and debris flows. The fire was most severe in the Bear Canyon and Coleman Canyon (Mission Creek) sub-watersheds. Lessons learned from this fire should be incorporated in future updates to this plan. (USFS Draft BAER report August 2008, MCWRA 2008)

Following the Basin/Complex fire that occurred during the development of this Watersheds Management Plan, an interesting observation was made by a member of the Steering Committee. Understory had burned so hot as to damage mature oak woodlands in some parts of the burned area. However, on the Los Padres National Forest grazing allotment which has been nearly continuously grazed for 40 years, Valley Oaks emerged unscathed. It was suggested that this area could be monitored over time to better understand grazing for fire management.

Causes of California Fires 2000 - 2005	
Lightning	5%
Arson	7%
Debris burning	10%
Miscellaneous	13%
Undetermined	14%
Vehicles	14%
Campfire	3%
Equipment Use	27%
Power Line	3%
Playing with fire	2%
Smoking	2%

Source: www.cdfdata.fire.ca.gov/incidents/incidents_statsevents

Figure 40. Causes of California Fires 2000 - 2005

A fire policy of suppression in these watersheds has allowed substantial increase in fuel loads and can have significant economic costs. Statewide fire suppression expenditures for 2005-06 were approximately $105 million (3/2006 www.fire.ca.gov). If fire frequencies increased, fire intensity and damage would be expected to decrease. Fire suppression is a strategy that only temporarily avoids severe wildfires that endanger human life and property as well as water quality and watershed health. The following paragraph clearly states the importance of local involvement in fire management and is relevant for these watersheds:

> *"Californians need to embrace a different model of how to view fires on these landscapes. Our response needs to be tempered by the realization that these are natural events that cannot be eliminated from (Southern) California. In this respect we can learn much from the science of earthquake or other natural disaster management. No one pretends they can stop them, rather they engineer infrastructure to minimize impacts, and in this respect there is much that can be done at the local level".* Jon E. Keeley in *Fremontia.*

In addition, consideration of differential suppression in different habitats is warranted as depicted by Zeke Lunder, Chief Fire Planner/Fire Management/GIS Planner for North Tree Fire International.

> *Suppression damage is not equal across the landscape. Some areas are more susceptible to damage than others. Some pastureland and chaparral areas recover quickly from bulldozer impacts while others do not.*

Mr. Lunder also suggests that suppression using dozer lines and other disturbances could be avoided in areas of serpentine soils in the watersheds which are rich in endemic species. Further Mr. Lunder suggests that a holistic approach for determining suppression techniques is needed to address the best suppression methods for specific situations. For example, while mechanized fuel treatment is to be avoided in erosion prone areas, this same treatment may inadvertently act to spread invasives species when used elsewhere in the watersheds.

A discussion of fire suppression, fire management strategies, and water quality concerns caused by fires should be part of the improved communication and coordination effort suggested below as a recommendation of this Plan.

GOAL: Reduce the risk associated with catastrophic wildfire impacts on life, property, and natural resources through increased public awareness and understanding of what causes these events.

OBJECTIVE 1: Work with California Department of Forestry and Fire Protection, US Forest Service, Camp Roberts, Fort Hunter Liggett, Bureau of Land Management, Fire Safe Councils and other appropriate parties to address fire protection and fuel load reduction while enhancing watershed health.

Implementation 1A: Encourage all agencies and landowners to reduce fuel loads using a diverse set of vegetation management tools such as grazing, prescribed burning, and mechanical equipment where erosion hazard is not severe. This would reduce the cost and losses in the residential interface zones caused by devastating wildfires.

Implementation 1B: Support Local Fire Safe Councils to include, but not be limited to, the following activities:
a) provide a forum for the community to give input and provide local knowledge to policy makers.
b) organize workshops on fire safe topics such as creating a defensible space and providing defensible space rebates
c) review, discuss, distribute and comment on Cal Fire's plan for the watersheds with particular attention to the following:

- Conditions of burn permits
- Roadside fuel reduction
- Coordination of public and private fuel breaks
- Community evacuation plans
- Effect on streams and riparian habitat

Implementation 1C: Gather information among all parties on methods available for managing risks for preventing destructive wildfires in the watersheds and distribute this information to appropriate watershed users.

Implementation 1D: Encourage wildland firefighting agencies to develop appropriate mitigation for the impact of fire suppression materials.

Implementation 1E: Obtain flyers for local distribution and plan educational workshops for watershed residents on topics such as :

Maintaining a defensible space,
Ensuring a sufficient water source for fire prevention
Landscape with fire resistant trees and shrubs
Other fire prevention landscaping techniques
Safety and emergency protocol development for the home
Evacuation plans for humans and animals

Implementation 1F: Develop and use GIS and other mapping technologies to establish prioritized sensitive areas to target appropriate fire suppression techniques and treatments.

Objective 2: Work with all agencies within the watersheds to consider elements of future development that would recognize the inevitability of fire and protect infrastructure property and vital watershed cover.

Implementation 2A: Encourage participation by residents in both watersheds to provide comments to future planning documents related to fire and fire management for carefully planned development away from forested areas and to ensure adequate defensible space is incorporated. This can be done on an individual basis or through existing or newly established Fire Safe Councils or other community associations.

Implementation 2B: Work with county and fire management entities to carefully plan any future development near or adjacent to areas of high fire potential and in areas that are difficult to provide fire protection. Support and/or conduct documentation of the increased damage that occurs when housing/other buildings are in proximity to forests and work with county planning departments to incorporate guidelines.

Implementation 2C: Encourage the Monterey District of the Los Padres National Forest to develop a Wilderness Areas Fire Management Plan for the Monterey District.

Implementation 2D: Encourage the cooperation of the fire departments and air pollution control districts in allowing controlled fire as a management tool on agricultural and rural lands in the watersheds. Work with agricultural land owners to permit the use of controlled burns to address excessive and overgrown underbrush.

Objective 3: Work with CalFire and US Forest Service (in light of the Basin and Indians fires) to include the community in rehabilitation of burned areas and to work toward increased preparedness for post-fire work.

Implementation 3A: Encourage fire agencies to include knowledgeable watershed residents in the planning of rehabilitation of burned areas. Encourage these agencies to work with watershed residents to prevent the premature mandatory evacuation of individuals who have the local knowledge needed by fire agencies to protect watershed residents and resources.

Implementation 3B: Encourage watershed residents to actively participate in Fire Safe Council and ensure information is passed to residents of the watershed to help them prepare for future fires.

Implementation 3C: Encourage Fire Safe Councils, fire agencies and residents to be prepared to contend with post-fire water quality issues that are as inevitable as the fire themselves.

Figure 41. CALFire aircraft dropping flame retardent
(Source: CALFire, 2008)

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ISSUE 6 – Taking Enforcement Action

ISSUE:

Inadequately enforced regulations result in negligent practices and illegal activities that can negatively impact water quality and watershed uses.

STATUS and REFERENCES:

In some cases, the most efficient and cost effective method for protecting water quality from point and nonpoint sources of pollution is to enforce existing regulations. Lack of adequate enforcement can lead to the following types of activities that may cause harm to water quality.

- grading without a permit causing erosion, sedimentation and transport of other pollutants
- littering and dumping of trash
- abandoned methamphetamine labs and hillside marijuana gardens
- vandalized public toilet facilities
- careless boat operation causing fuel leaks or shoreline erosion
- vandalized boat docks spreading Styrofoam and other debris in the reservoir

Activities that do not necessarily affect water quality, but that are priorities to prevent in these watersheds include:

- removal of oak trees under certain conditions and in specific locations
- disturbance or destruction of cultural resources

GOAL: Enforce existing regulations, laws and ordinances that will help protect water quality and watershed health.

Objective 1: Support jurisdictional entities to use their existing authority rather than develop new regulations.

Implementation 1A: Encourage cross-jurisdictional communication to identify barriers to and potential improvement of enforcement.

Implementation 1B: Communicate boating regulations and watershed protection measures at each entrance to the reservoirs through handouts, signage, etc.

Implementation 1C: Encourage MCWRA and San Luis Obispo county to work together with local groups to develop materials (pamphlet, brochure) explaining existing regulations, jurisdictional areas, and available services and resources for use by residents and visitors.

Implementation 1D: Encourage San Luis Obispo County to do more to educate homeowners about existing grading and erosion control regulations and to better enforce those regulations.

Implementation 1E: Support the development of a management plan that involves community input and participation as required for the Milipitas Special Interest Area. This Area was designated by the US Forest Service in the Los Padres National Forest Plan in order to protect cultural resources and cultural landscape of the upper watershed.

Implementation 1F: Encourage landowners to consult with UC Cooperative Extension, Resource Conservation Districts, Farm Bureaus and others for erosion and sediment control programs.

Objective 2: Encourage the public to become familiar with and utilize Cal Fire Standards for protecting homes and properties.

Implementation 2: Include Cal Fire Standards 1 – 8 (methods for defending residential properties against fires) in a 'Watershed Citizens' guide which is recommended under other Goals in this Chapter. These standards include: maintaining a defensible space, ensuring a sufficient water source for fire prevention, landscape with fire resistant trees and shrubs, other fire prevention landscaping techniques, safety and emergency protocol development for the home, evacuation plans for humans and animals.

Objective 3: Encourage the public and all jurisdictional entities to become familiar with existing laws that protect cultural resources such as California Environmental Protection Act (CEQA) for local and state projects and the National Environmental Protection Act (NEPA) for federal projects or projects on federal lands. Cultural resources can include archaeological sites, historic sites, actual locations, landscape features, and specific plants.

Implementation 3A: Recommend funding for a CEQA workshop to be made available to local county staff, landowners, and private consultants working on both private and public projects to cover all aspects of the law and implementation, not just the cultural resource aspects.

Implementation 4A: Because of the prevalence of archaeological and historic sites in these watersheds, develop a user friendly manual on how to comply with CEQA when cultural resources may exist in a project area and how to handle burial sites if found with reference to the governing laws.

The following two Objectives are specific to the enforcement of the San Luis Obispo County Stormwater Management Programs and Ordinances:

Stormwater Management Objective 1: Improve erosion and sediment control for new development and redevelopment as part of County Stormwater Management Programs.

Implementation 1: Conduct community outreach regarding new County Stormwater Management Program requirements that include more frequent, comprehensive grading/ stormwater inspections and enhanced enforcement of violations as provided for in new County ordinances and new inspection programs scheduled to be implemented between 2010 and 2011.

Stormwater Management Objective 2: Detect and eliminate illicit discharges within urban areas according to the new County ordinance.

Implementation 2: Enforce the new County Stormwater Pollution Prevention and Discharge Control Ordinance. Agriculture is specifically exempted.

ISSUE 7 – Coordination & Communication

ISSUE:

Ineffective coordination and communication between and among counties, jurisdictional entities, regulatory entities, community groups and residents in the watersheds can negatively impact water quality and watershed uses.

STATUS and REFERENCES:

Lack of coordination and communication between large public land managers (such as the military, national forest, MCWRA) and local community's presents challenges in protecting water quality and watershed uses. Coordination and communication among agencies and communities can deter the spread of invasive species from one location to another (Yellow star thistle, Quagga mussels, certain algae species, white bass, other invasives) and pool resources and information to cooperatively manage resources (possible examples include: Tank Road use and impacts, grazing lands, fire management, water quality monitoring, clean up of marijuana growing sites in upper watersheds).

Increasing communication and coordination among the various parties in these watersheds can prevent the loss of watershed uses and ensure protection of water quality. Public agencies and governmental representatives such as County Supervisors should maintain a watershed-wide perspective and strive to be responsive to issues and conditions in smaller, sub-watersheds.

Members of Steering Committee, TAC and members of the public rank their top issues and concerns in the watersheds

Figure 42. (Source: MCWRA, 2007)

From the public agency perspective, cooperative partnerships are the most cost effective way to manage public resources with limited funding. These two watersheds are in two counties. In both watersheds there are large landowners whose actions can have a significant effect on the management of watershed resources. In both watersheds, private landowners are largely dependent on the Monterey County Water Resources Agency's water resources for the development and enhancement of their investments. Those water resources in turn, are dependent upon good stewardship of other lands in the watersheds. By working in a more coordinated and cooperative manner, the two counties can identify issues and develop solutions before a regulatory action is considered necessary by outside agencies.

An important tool that will enable counties and other entities to discuss and address issues that arise is an inventory of existing data sources and programs for these watersheds. The *Watershed Resources Inventory* (WRI) of this Plan located in Appendices A is a step in that direction with over 200 source references concerning water supply, water quality, extent and condition of natural resources. The MCWRA is the repository for the documents contained in the WRI where source materials will be maintained as a discrete collection so that it can be systematically added to with the additions tracked over time.

GOAL: Achieve coordinated efforts between and among jurisdictional entities, regulatory entities, community groups, residents, and other individuals in the watersheds to manage watershed resources in the most effective manner transcending political boundaries and protecting property rights.

OBJECTIVE 1: Bring regulatory and jurisdictional entities together in conversation with local watershed users through "roundtable" discussions to develop cooperative guidelines, achieve common goals and exchange perspectives for the management of watershed resources and protection of water quality.

OBJECTIVE 2: Achieve improved and effective working relationships by determine appropriate nexus for partnerships to obtain funding in support of these roundtables.

Implementation 2A: Function and Objectives of proposed Roundtables:

Each of the roundtables is proposed as an implementation measure and could integrate with others as cross-over of issues becomes important and individual liaisons are no longer adequate for collaboration. Roundtables could function to:

- Identify roles and responsibilities for managing the watersheds cooperatively, for the purpose of protecting water quality and watershed uses.
- Develop and implement cooperative guidelines that commit the agencies to a formal cooperation leading to a comprehensive public process.
- Ensure cooperative guidelines will achieve common goals using common terminology.
- Explain and understand regulatory mandates, jurisdictions of each entity, and existing laws
- Host community forums to gather concerns and explain cooperative guidelines
- Provide a forum for project proponents to explain projects and potential watershed and water quality impacts
- Develop liaison relationships with other roundtable groups to share information and coordinate as needed
- Conduct education and outreach to the community (Example: develop Watershed Stewardship Guide modules for use by all watershed users).
- Discuss methods for the cooperative management of watershed uses and resources and the prevention of point and nonpoint source pollution
- Review and incorporate technical information provided by scientists and engineers

Implementation 2B: Inter-County Task Force on land use and water resources planning:
Staff of appropriate county departments and elected officials work to identify opportunities for coordination and resolve existing or potential future conflicts related to watershed management, water quality protection, and water supply issues.

Develop goals, strategies and actions that each county can agree to by taking the following cooperative steps:

- Clearly identify roles and responsibilities for effective management of Nacimiento Reservoir and the surrounding lands.
- Each county lists their needs related to the watersheds;
- Overlay each county General and Specific Area Plans and Elements along with its land use and grading ordinances, Integrated Regional Water Management Plans and Stormwater Management Plans, etc for the watersheds. Identify operational gaps or unnecessary overlaps and discuss alternatives. Example: a cooperative effort to correlate land use designations between the two counties took place to develop the GIS data for this Nacitone plan.
- Discuss disagreements or miscommunications regarding each jurisdictional entity's role and responsibility

Topics that could be addressed by this group: Preventing nonpoint source pollution; design standards for roads and culverts in the watersheds proper marina and dam operations, etc.

Implementation 2C: Water Quality Monitoring & Information Exchange:
Increase opportunities for coordination among the various groups conducting water quality monitoring in the watersheds through development of common protocol and sharing of data. Compile an inventory of monitoring efforts noting frequency of sampling, parameters, and locations. *See the Water Quality Monitoring goals and objectives section for more specifics.*

Implementation 2D: Recreation roundtable:
Expand the existing information exchange between Monterey County Park Rangers and watershed residents on enforcement issues to include Monterey County Water Resources Agency (MCWRA) and the Nacimiento Regional Water Management Advisory Council (NRWMAC) to:

- Address invasive species threat and work with counties to coordinate prevention efforts
- Provide updates on the water projects (Salinas Valley Water Project and the Nacimiento Water Project);
- Provide more timely reservoir release schedule information;
- Update county entities on study of alternative release scenarios;
- Keep county informed on issues or conditions related to recreational use of the reservoirs.
- Address water quality impacts of recreational activities

Implementation 2E: Livestock grazing roundtable
Bring together private and public owners/operators of grazing lands to discuss their various livestock grazing goals and develop options consistent with common goals for water quality protection. Encourage involvement of other interested parties. A first step might be to evaluate the possibility of developing a coordinated grazing program for both watersheds in order to stimulate positive, working relationships with local land and livestock owners. Possible steps are:

- Develop livestock grazing options consistent with common goals
- Inventory the available grazing acreage and steps that would need to be taken to expand that acreage.

- Evaluate the options
- Implement the options in a cooperative agreement committing agencies to an open public process.

Implementation 2F: Neighborhood Road Associations

Groups of residents along county or non-county roads meet to determine short and long-term goals and objectives and take cooperative actions such as periodic clean-ups. Support to these groups could be provided through Resource Conservation District and/or Natural Resources Conservation Service programs. These groups could provide community support to RCDs/NRCS or county departments in seeking funds to conduct road improvement projects. These associations could also be community forums for learning about other issues such as fire management, water quality protection practices, etc.

- **Review county design standards for roads and culverts**
- **Review Low Impact Development methods for roads and proper installation and maintenance of culverts**
- **Identify and plan for the management of roadside vegetation where needed**
- **Conduct roadside clean-ups**

Implementation 2G: Invasive Species Roundtable

Aquatic: This would be a formalization of the existing cooperative efforts taking place between the two counties and with the Department of Fish & Game, residents, and visitors to prevent the invasion of Quagga/Zebra mussels into Nacimiento and San Antonio Reservoirs.

Terrestrial: This group would work in conjunction with the county Weed Management Areas to coordinate activities and funding to eradicate invasive plant species and animal species as needed.

OBJECTIVE 3: Continue the Nacitone Watersheds Steering Committee by seeking funding and contracting with a watershed coordinator/grant writer.

ISSUE 8 – Watershed Health: Plants & Animals

ISSUE:

The ecological interactions among plants, animals and the physical environment are integral to the maintenance of water quality and watershed uses. As the watersheds experience changes through development, ecological interactions may be impaired as habitats are altered. Woodlands for example provide important soil production and water retention services vital to the recharge capability of the local hydrology. They also provide important habitats for possible threatened species dependent upon them. The available documentation on the biota of the watersheds is almost entirely from federal lands. There is a need to inventory and track cumulative impacts to the watershed to ensure that water quality and watershed uses are not impaired.

STATUS and REFERENCES:

According to several studies between 1991 and 1997 (Pavlik et al.) the presence of oak trees increases soil productivity and may enhance water quality, forage quality, species diversity, and wildlife habitat. Both Monterey and San Luis Obispo counties have existing ordinances to protect oak trees. The US Forest Service has designated an area in the upper San Antonio watershed as the Valley Oak Research Natural Area since it contains the last stand of Valley Oak savannah on National Forest land. This area is open for scientific study on a multitude of topics including why there has been poor oak tree regeneration. The designation of this research area does not change any uses of the land.

The Blue Oak Woodland habitat of FHL comprises about 32% of the installation. It occurs in pure stands and in open savanna communities. Blue oak is the most frequently recorded and dominant species in all three types of blue oak communities.

The Nacimiento Reservoir is home to at least three of multiple active bald eagle nesting sites on the Central Coast. It also has a viable large and smallmouth bass population and is the only reservoir in California stocked with white bass. The Nacimiento River watershed has habitat that is capable of supporting the California Tiger Salamander. The Nacimiento River below the dam is listed as a steelhead river.

The San Antonio reservoir is one of the largest eagle winter habitats in Central California. Over 60 eagles, both bald and golden, have been counted around the reservoir. The upper San Antonio watershed is a nesting site of the protected California condor with a range from the Pacific Ocean to the Pinnacles National Monument. The Department of Fish and Game is responsible for enforcing a current no-lead bullet law within Condor habitat pursuant to Assembly Bill 821 enacted into law in 2007 establishing section 3004.5 of the Fish and Game Code relating to Ammunition Certification for big game and nongame bird and nongame mammal hunting in Condor Range. The ultimate purpose of using ammunition and projectiles certified to contain no lead is to ensure that hunters are not exposing condors to secondary lead poisoning.

San Antonio reservoir has a variety of fish species with catfish and largemouth bass being two of the most popular amongst fishermen. The San Antonio watershed provides habitat for several species designated as either threatened or endangered by the U.S. Fish and Wildlife

Service including the endangered Arroyo Toad, San Joaquin Kit Fox and the threatened California Tiger Salamander.

Vernal pools, which are seasonal wetlands, are also found in the San Antonio watershed and provide habitat for species like the California Tiger Salamander. Statewide, over 90% of these small, valuable and threatened vernal pool ecosystems have already been lost. The San Antonio Valley contains 84 mapped pools in areas with vehicle and ground disturbance limitations or they are located in Fort Hunter Liggett Sensitive Resource Protection Areas (SRPs). (Additional information about resource protections in place is contained in Part 4: Jurisdictional and Existing Regulatory Framework).

Goal: Maintain ecological and watershed functions that support water quality by increasing awareness of all stakeholders

Objective 1: Establish scientific basis for recognizing cumulative impacts to watershed health.

Coordinate with private and public land owners/managers, Camp Roberts, Fort Hunter Liggett, Los Padres National Forest, RCDs, county planning staff, county Agricultural Commissioners' Weed Management Area efforts to do the following:

Implementation 1A: Identify suitable models for tracking and calculating cumulative impacts of human activity and natural changes upon plant and animal communities.

Implementation 1B: Develop and maintain an inventory of plants and animals in these watersheds.

Implementation 1C: Provide biological surveys on lands owned by parties interested in scientifically documenting the present status as part of the above-mentioned inventory.

Implementation 1D: Recognize the effectiveness of Monterey County's oak tree ordinance and work with San Luis Obispo county landowners and planners to determine possible protection needs in Nacitone watersheds in that county.

Objective 2: Establish outreach and education programs to protect watershed health.

Implementation 2A: Support entities responsible for enforcing the use of non-lead bullets for hunting in the watersheds by distributing information on the law and the effects of lead bullets on wildlife, especially California condors, and upon people if animals shot with lead bullets are consumed.

Implementation 2B: Develop and provide, to interested landowners, balanced information about the Williamson Act, conservation easements and projects proposed by land trusts. This information would hi-light the legal commitment on the part of the landowner; types of conservation easements; and options for negotiating allowable activities on any contemplated conservation easement.

Implementation 2C: Foster and support a stewardship ethic among watershed users by incorporating information on all of the above into a "Watershed Stewardship Guide" module within a series of guides. This module might be named for the title of this section, *Watershed Health: Plants & Animals* and would be developed in coordination with Monterey County Parks and other appropriate entities.

Implementation 2D: Encourage and support local communities to pass to younger generations the importance of protecting watershed uses and watershed resources.

Implementation 2E: Provide factual information to make the public aware of how a "wild and scenic" designation under the federal Wild and Scenic Rivers Act affects public and private lands along the north and south fork of the San Antonio River through the Ventana Wild and Scenic Rivers Proposal and the Final Environmental Impact Statement for the Southern California Forest Plan Revisions.

Figure 43. Oak Woodlands on USFS grazing alottment in San Antonio Valley

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ISSUE 9 – Roads & Culverts

ISSUE:

Roads have been identified as a major source of water pollution in watersheds throughout the United States. In addition to water quality impacts, poorly built roads result in higher maintenance costs to landowners, can cause significant property damage and can be less safe than properly built roads. Some roads and culverts in these watersheds were built or designed to handle less runoff than they are receiving and are therefore in need of re-design and/or more regular maintenance.

STATUS and REFERENCES:

Erosion and resulting sedimentation is a natural process often accelerated by human activities. Excessive sedimentation clouds water, which reduces the amount of sunlight reaching aquatic plants; covers fish spawning areas and food supplies; and clogs the gills of fish. In addition, other pollutants such as phosphorus, pathogens and heavy metals are often attached to the soil particles and end up in downstream water bodies.

A significant but manageable source of erosion and sedimentation in most watersheds is roads. Paved and unpaved roads exist throughout the upper, mid and lower Nacitone watersheds both on private and public land. Road and culvert design, construction, and maintenance practices, if not well planned, can concentrate water, causing accelerated erosion and possibly road washouts sending sediment downstream.

Unpaved roads can generate more sediment than paved roads and are higher priorities for design, construction and maintenance to minimize erosion. There are unpaved roads in all portions of these watersheds. The largest amount of unpaved roads occurs on the two military installations. However, there are areas throughout the two watersheds on both private and public lands with higher road densities than the averages listed in figure 40. In a 2001 study of erosion sources, Lewis Et. Al (California Agriculture 55(4):32-8) found that roads were a larger sediment source on ranches than grazing.

A brief assessment of roads was conducted by the MCWRA for this watersheds plan. The assessment consisted of two parts. The roads of both watersheds were assessed using GIS and roads on MCWRA land were assessed by the US-LS RCD.

The GIS assessment found many old roads and firebreaks that do not appear to have been used for many years, and appear to be possible sources of sediment to stream channels in both watersheds. Data sets were created to calculate the number of linear miles of roads. Road surface material and ownership classification as either public agency or private roads was also collected. Ground truthing was limited and was only done on a few easily accessible roads. The two watersheds contain a little over 2,300 linear miles of roads. There are 315.3 miles of paved roads and 1,985.8 miles of dirt roads and fire breaks that exist in these two watersheds. Given a watershed area of 705.3 square miles, this yields a road density (linear miles of road per square mile of area) of 3.26.

In addition to MCWRA analysis of roads, the US-LT RCD visited the eight agency leases and did a quick assessment of road impacts. The RCD determined that the Tank Road (or "Tank Trail") and ranch roads on MCWRA parcels around both reservoirs are potentially significant sources of erosion and sedimentation into the reservoirs that could have negative water quality impacts. Both military facilities in the Nacitone have easements to use the Tank Road which is owned by MCWRA and is an important route between the two facilities.

Existing Road Infrastructure

	Total (linear miles)	Paved Roads (miles)	Dirt Roads & Fire Breaks (miles)	Road Density (square miles)
Both Watersheds	**2,301.2**	**315.3**	**1,985.8**	**3.26**
San Antonio River Watershed	1,272.3	183.5	1,088.8	3.70
Nacimiento River Watershed	1,028.9	131.8	897.1	2.84

Source: MCWRA, 2008

Figure 44. Existing Road Infrastructure

culverts and developing a plan to reduce their negative impacts. Such surveys have been done in many other watersheds using aerial maps and field work to ground truth locations of highly erodible soils, steep slopes, and other conditions to prioritize roads for upgrade, maintenance, or re-routing.

GOAL: Maintain or enhance water quality and watershed health by minimizing accelerated erosion resulting from roads and culverts in these watersheds.

Objective 1: Fund the development of a roads survey through a coordinated effort among the two counties, military, and forest service staff and willing private landowners. Include in this project the development of a watershed-specific guidebook and workshop for private contractors, landowners, and staff of public entities.

Implementation 1A: Request that the two counties evaluate current design standards for roads and drainage structures to ensure they are sufficient to protect water quality in these watersheds and that these standards are provided to contractors, developers, and landowners in a clear and understandable format.

Implementation 1B: Seek funding to conduct road system surveys, prioritize potential problem areas, and prepare projects to be "ready for implementation" as funding becomes available.

Objective 2: Rebuild, properly maintain, and repair existing roads and prudently develop and build any new roads.

Implementation 2A : Provide road and culvert design, construction and maintenance educational materials and/or workshops for private contractors and landowners / land managers using already developed materials such as the "Handbook for Forest and Ranch Roads" by Pacific Watershed Associates for private roads.

Implementation 2B: Seek funding to conduct a focused survey on the Tank Road which runs from Fort Hunter Liggett to Camp Roberts and passes over MCWRA land on the north shore of the San Antonio reservoir. The survey and proposed upgrades to the road should be developed in a coordinated effort among the MCWRA, the RCD, the U.S. ARMY and the California National Guard at Camp Roberts.

Implementation 2C: Encourage landowners to seek technical assistance from various agencies, private consultants, or groups such as the Natural Resources Conservation Service (NRCS) and the Resource Conservation Districts (RCDs) to minimize accelerated erosion resulting from roads and culverts on their private lands. Ensure landowners are aware of cost-share, incentive programs that may be available for road improvement projects.

Implementation 2D: Encourage the US Forest Service to develop a management plan for the Milpitas Special Interest Area that addresses unauthorized/unclassified (non-system) roads on their lands in that area. (A map of these roads is included in Appendix J).

Figure 45. Dirt road on MCWRA property
(Source: MCWRA, 2006)

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ISSUE 10 – Education & Outreach

ISSUE:

Information about existing conditions within these watersheds, watershed functions, how human uses can affect water quality and how we can protect the watersheds are important for everyone living in, working in, and visiting these watersheds.

GOAL: Increase the awareness and understanding of water quality, watershed uses, and watershed functions by those living in, working in, and enjoying the watersheds.

Objective 1: Work with other entities and their existing publications to ensure there are effective materials and programs made available to all watershed users.

Implementation 1A: Develop a catalogue of existing printed material and websites that are available for watershed residents and visitors with information on the following: (this list is not intended to be exhaustive and will be added to over time).

- How to identify methamphetamine labs, marijuana growing sites and who to contact or what to do about them
- Invasive, exotic plant species and plant disease hit list and control measures
- Invasive, exotic insect / animal species hit list and transfer prevention measures
- Shoreline erosion processes – how you can prevent it
- Boat and boating laws
- Information on the prosecution of vandals
- Fire prevention – Cal Fire standards for defensible homes
- The water projects : what, where, why, and how for the Salinas Valley Water Project and the Nacimiento Water Project
- Water conservation measures and new technologies for homeowners and farmers
- Cultural resources – why they are important and how to appreciate them
- Historic resources – biking map with narratives on adobes, classic views, streams, the mission, wineries, etc.
- Plants & Animals of the watersheds
- What is "wild and scenic" and what could it mean to you?
- Ecological diversity and cattle grazing
- Mercury: why should you care? (water, soil, fish tissue, air)
- Trash in streams/lakes: life cycle of a Styrofoam cup
- How to keep petroleum and other pollutants out of streams/lakes
- Septic Safe education – how to use septic-safe household chemicals and soap; doing your own regular inspections
- Stormwater pollution prevention
- Low Impact Development measures for new and significant re-development projects
- Homeowners guide to preventing nonpoint source pollution
- Wildfire prevention
- Fire evacuation plans for humans and animals
- Low Impact or Zero Impact Camping

Implementation 1B: Encourage and support local communities to pass to younger generations the importance of protecting watershed uses and watershed resource through schools, farm days and 4H. *(Note: Annual "Farm Day Experience" events have occurred in King City for approximately the past 10 years. This event hosts 1,000s of third graders to learn about farming, ranching, and the resources they depend upon).*

Implementation 1C: Periodically offer Grazing and Irrigated Ag Water Quality Short Course as a cooperative program of the UC Cooperative Extension Services, Farm Bureau, RCDs, NRCS and the MCWRA.

ISSUE 11 – Invasive Species

ISSUE:

Non-native exotic species have historically entered these watersheds. Some exotics are invasive as they rapidly out-compete native species for habitat and can degrade watershed uses. Invasive species threaten the diversity or abundance of native species through competition for resources, predation, and parasitism, interbreeding with native populations, transmitting diseases, or causing physical or chemical changes to the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy. Examples of direct impact to human activities include the clogging of navigable waterways and water delivery systems, weakening flood control structures, damaging crops, introducing diseases to animals that are raised or harvested commercially, and diminishing sport fish populations. Management of invasive plants and animals through grazing, cultivation techniques, and physical/chemical eradication methods often occurs in an independent and uncoordinated manner by individual landowners or by land managers within differing jurisdictions.

GOAL: Maintain or enhance water quality and watershed health by increasing cooperative efforts among landowners and managers regarding invasive exotic plants and animals.

Objective 1: Prevent the introduction of invasive species and diseases into the watersheds including the reservoirs (examples: sudden oak death, Quagga/Zebra mussels, giant bamboo, tamarisk, etc.)

Implementation 1A: Encourage interagency cooperation on measures required to prevent the introduction of invasive species.

Implementation 1B: State and local agencies, and resident associations should continue to provide information through informational brochures and signage to incoming boaters and other watercraft users or other recreationalists on the problems associated with specific invasive species, the potential consequences, and how they can help prevent the introduction of these species.

Implementation 1C: Monterey County, San Luis Obispo County and resident associations should work together to develop and implement programs to control invasive species.

Implementation 1D: Provide factual, educational materials about the potential to spread Sudden Oak Death by transporting firewood from areas where the disease occurs, i.e. along the Big Sur coastline.

Implementation 1E: Prevent the entry and spread of exotic and invasive species.

Objective 2: Control the spread of invasive species in the watersheds including the reservoirs (example: yellow star thistle).

Implementation 2A: Encourage landowners and homeowners to control the spread of exotic and invasive plant and animal species.

Implementation 2B: Work with each county's weed management area and the California Department of Fish and Game's Invasive Species Program.

Implementation 2C: Create an open dialog about the use of mechanical and chemical means as well as burning and grazing for controlling noxious weeds, improving habitat and improving the health of the grasslands of the Nacitone watersheds.

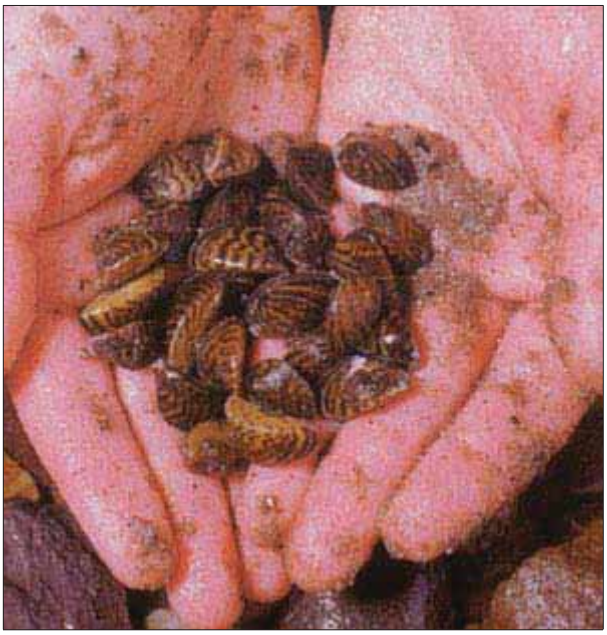

Figure 46. Zebra mussels
(Source: CA Dept. Fish and Game)

E. From recommendation to Action: A Living Plan

The Nacitone Watersheds Management Plan represents a written plan demonstrating an accumulation of facts, figures, and implementation recommendations. Less evident are the myriad relationships that have grown out of the process of stakeholder meetings. The interactivity and relationship building that has occurred will be a critical component of the success and longevity of the plan.

As the Steering Committee reflects on the efforts thus far extended to produce the plan, it has considered the following methods for better ensuring the plans contents are utilized to the fullest extent possible.

Immediate Steering Committee Actions

The Steering Committee has agreed to begin setting into motion the following tasks:

1. Presenting the plan to both County's Boards of Supervisors
2. Identifying subsequent grant opportunities to capitalize on implementation recommendations
3. Configuring a Watersheds Advisory Committee (WAC) which would shepherd the plan forward until such time as a staff position is identified and funded to work with the WAC to support water protection efforts in the Nacitone watersheds.
4. Distributing this plan in coordination with the Monterey County Water Resources Agency
5. Consideration of a user-friendly format for the plan to encourage wider public appeal
6. Facilitating the prioritization and forward momentum of implementation actions. Determining which of the implementations to facilitate and/or implement.
7. Choose a date for the next stakeholders meeting to be convened by the WAC

Method for Plan Distribution

<u>Public Outreach</u>

To the extent possible, Steering Committee members may 'shop the plan around' to groups and associations whose missions have a nexus with the plan. The Steering Committee has been contacting those identified as potential partners for implementation recommendation and will continue to solicit participation in the form of idea exchange and generation of next steps to kick off implementation recommendations.

<u>Targeted Entities</u>

The following groups will receive copies of the plan.

- Technical Advisory Committee members representing jurisdictional agencies in the watersheds
- Representatives of jurisdictional agencies identified in the jurisdictional section of the plan
- Chairpersons of each County Board of Supervisors

- Specific staff members of each County such as Public Works Directors, Planning and Building Department Directors, Reservoir Operations Committee of MCWRA
- People providing public comment
- Steering Committee members
- Members of the public upon request

In addition, the following electronic venues will be used to distribute the plan.

- Nacitone Watershed Group website
- Monterey County Water Resources Agency web site
- Request links on jurisdictional web sites

Strategic Planning

The goals and objectives of this plan may be beneficial starting places for both Counties when they pursue up-dates of General Plan elements relative to these watersheds. Future groups should refer to County General Plans for policies that may support or prevent implementing the Plan's goals and objectives.

Future of the Nacitone Watershed Group Funding

The following is a list of potential strategies for consideration.

1. MCWRA and SLO County Public Works to collaborate on a grant to fund a watershed coordinator.
2. Current watershed group to draft a Memorandum of Agreement (MOA) of potentially involved parties and identify roles and responsibilities of involvement. MOA could be structured to include public agency, local non-governmental organization (NGO), and local sponsoring agency (existing water quality interests) for each county. MOA could be structured to include local, regional, state and federal organizations and agencies that hold a stake in the health of the watersheds. MOA could be structured with signatories' agreement to financially contribute to support a scope of work derived from the MOA.
3. Pursue Supplemental Environmental Projects arising out of RWQCB or other agency violations. For example, Tract 1990 has been levied a fine, some portion of which could be assigned to projects arising out of the NWMP.

Future Plan Updates

As new information on the condition of the watersheds becomes available and new actions to protect and enhance watershed health are agreed upon by stakeholders, the plan could be updated based upon the guidance and direction of the WAC. This plan is not intended to be modified or revised by entities other than a stakeholder or similar group. In addition, as implementation recommendations are acted upon, successes will be accumulated. There will be a need to track the outcomes of the recommendations, monitoring for water quality improvements over the long term.

F. Pending Changes to the Watershed

At this time, the Nacimiento and Salinas Valley Water Projects are being built and will be operational by 2010. A synopsis of both projects is provided below.

Salinas Valley Water Project (SVWP)

The SVWP has several components. Only part of Phase1 would be included in the infrastructure of the Nacitone Watersheds, including spillway modifications to the Nacimiento Dam and re-operation of the reservoirs. Modification of the spillway will increase the capacity of the spillway so it would be able to pass the probable maximum flood (PMF) event. Construction of the Nacimiento Dam spillway modifications include lowering the existing spillway crest approximately twelve feet to an elevation of 788 feet, installing a twelve and a quarter-foot high inflatable rubber dam and raising and strengthening the side walls of the existing spillway chute. Although the maximum capacity of the reservoir would not be altered, larger storm flows can be passed by the spillway. The spillway modification at Nacimiento would allow the MCWRA to're-operate' the reservoir to increase the amount of water stored during the winter and released during the spring and summer months for conservation (i.e., groundwater recharge through the Salinas River bed) and, ultimately, for downstream diversion. The MCWRA currently operates both reservoirs, and although no physical modifications at San Antonio would occur, both reservoirs are operated as a system such that more water would be available for release (SVWP EIR, 2002; SVWP 100% Design Submittal, Boyle Engineering, Feb 2007).

The following significant impacts were found to be unavoidable regarding the SVWP: potential effects on largemouth bass spawning in Nacimiento Reservoir; a reduction in aesthetic values and recreation at the reservoirs; and short-term, construction-related air emissions. The MCWRA Board of Supervisors determined that the benefits of the project overrode the need to avoid those impacts. Therefore, on June 4, 2002, the Board of Supervisors issued a Statement of Overriding Considerations as provided in CEQA Guidelines section 15093 (SWRCB Notice of Petition to Change the Place of Use and Add Points of Diversion 2004).

Nacimiento Water Project

In 1959, San Luis Obispo County Flood Control and Water Conservation District obtained entitlement to 17,500 acre-feet of water per year from Nacimiento Reservoir by an agreement with the Monterey County Water Resources Agency. The project to convey raw water from the reservoir to contracting entities involves a 45-mile pipeline, three tanks, and a multi-port intake facility at the reservoir. Only the intake structure and a small portion of the pipeline lie in the watershed study area. The project is intended to supplement the San Luis Obispo County water supply (SLO County Public Works brochure, 2007). Contracting communities include Paso Robles, Templeton, Atascadero, San Luis Obispo, and County Service Area 10, Benefit Zone A.

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Part 4
Jurisdictional and Existing Regulatory Framework

The NACITONE watershed falls under the jurisdiction of many local, state and federal government agencies. In addition, there are numerous non-regulatory entities that exist and have various missions and functions. A first step toward cooperative management of these watersheds across regulatory and non-regulatory entities is to understand the jurisdictions, roles and responsibilities of these entities. The following section gives a brief overview of regulatory agencies and non-regulatory entities that function in one or both of these watersheds.

A. Regulatory Agencies

Regulatory refers to policies that are forms of legal restrictions that are carried out by the government. The following lists regulatory agencies that have jurisdiction within the NACITONE Watershed and which have a substantial regulatory presence.

Federal Agencies

Federal Energy Regulatory Commission (FERC)

Mission: The Federal Energy Regulatory Commission regulates and oversees energy industries in the economic, environmental, and safety interests of the American public.

Authority: The Federal Energy Regulatory Commission is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity, as well as natural gas and hydropower projects. FERC is responsible for licensing and inspecting private, municipal, and state hydroelectric projects. FERC also oversees environmental matters related to natural gas and hydroelectricity projects and major electricity policy initiatives. The Energy Policy Act of 2005 gave FERC additional responsibilities as outlined in FERC's Top Priorities and updated Strategic Plan.

Guiding Document: FERC Strategic Plan

FERC is responsible for all regulations related to dam/spillway safety requirements at Nacimiento Reservoir. The FERC is headquartered in Washington, DC and also has a regional office in San Francisco.

Relevant websites: http://www.ferc.gov/about/about.asp and http://www.ferc.gov/industries/hydropower/safety.asp

National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service

NOAA Fisheries is a division of the National Oceanic and Atmospheric Administration (NOAA).

Mission: Stewardship of living marine resources through science-based conservation and management and the promotion of healthy ecosystems

Authority: Several major statutes or laws form the legal basis for the programs of the National Oceanic and Atmospheric Administration; Coastal Zone Management Act, Endangered Species Act, Magnuson-Stevens Fishery and Management Act, Marine Mammal Protection Act, National Marine Sanctuaries Act.

Enforcement activities are carried out in cooperation with other State and Federal agencies in the Southwest Region to ensure compliance with various federal regulations relating to stewardship of fishery and protected species resources. For example, NOAA Fisheries works locally with the Army Corps permitting process by providing "Biological Opinions" on proposed projects. These opinions describe potential impacts to protected species and contain restrictions and appropriate mitigations that assure protection of these species during project implementation. Private land owners can work with NOAA Fisheries to develop Habitat Conservation Plans in order to obtain incidental take permits under the Endangered Species Act.

Guiding Document: The NOAA Fisheries Strategic Plan contains three goals: rebuilding and maintaining sustainable fisheries, promoting the recovery of protected species, and protecting and maintaining the health of coastal marine habitats.

The NACITONE Watershed is located in the NOAA Fisheries' Southwest Region which includes California, Hawaii, and the Pacific Trust Territories; the headquarters are located in Long Beach, California. The region is responsible for managing fisheries off the coast of California for salmon, ground fish, and anchovies; and/or conducting enforcement, marine mammal and habitat programs to protect fishes, marine mammals and endangered species within the region. The Southwest Region Field Office is located in Santa Rosa, California. The field office's primary purpose is the administration of the Endangered Species Act, particularly the protection of listed salmonids including Coho, Chinook Salmon, and Steelhead Trout. NOAA Fisheries is also responsible for administering the Clean Water Act, Federal Power Act, Fish and Wildlife coordination Act and the Magnuson-Stevens Act.

Relevant websites: http://swr.nmfs.noaa.gov/ and http://www.lib.noaa.gov/noaainfo/heritage/heritage.html

United States Army Corps of Engineers (ACOE)

Mission: The Army Corps of Engineers' missions include five broad areas of water resources, environment, infrastructure, homeland security and warfighting. The water resource mission is 'in support of Nation's interests, build broad-based relationships and alliances to collaboratively provide comprehensive, systems-based, sustainable and integrated solutions to water resources national and international challenges'. The Corps environmental mission has two major focus areas: restoration and stewardship. Efforts in both areas are guided by the Corps environmental operating principles, which to balance economic and environmental concerns.

Authority: The legislative origins of the program are in the Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 U.S.C. 401, et seq.). The Congress of the United States has assigned the U.S. Army Corps of Engineers the responsibility for regulation and construction and other works in the waters of the United States. The Corps is charged with protecting our nation's harbors and navigation channels from destruction and encroachment, and with restoring and maintaining environmental quality. The principal regulatory mechanisms of the Army Corps that relate to watershed enhancement are the Clean Water Act, Section 404(b)(1) Guideline;

Marine Protection; Research and Sanctuaries Act; Endangered Species Act; National Historic Preservation Act; Coastal Zone Management Act; National Environmental Protection Act; and others as they relate to the regulatory actions of the District. Army Corps of Engineers permits are needed for any work done below the ordinary high water mark of a freshwater entity, discussion with an Army Corps of Engineers representative must be done prior to applying for a permit. According to the Army Corps of Engineers website, responsibilities are accomplished by regulating activities in three areas (1) discharge of fill or dredged materials in coastal and inland waters and wetlands; (2) construction and dredging in navigable waters of the United States; and (3) transport of dredged materials for dumping into ocean waters. The Army Corps of Engineers defines Navigable Waters on their website as the following "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or destroy navigable capacity".

Guiding Document: Civil Works Strategic Plan

The NACITONE Watersheds lies within the San Francisco District of the South Pacific Division of the Army Corps of Engineers. The local Army Corps of Engineers office is located in San Francisco, California.

Relevant websites: http://www.spn.usace.army.mil/ and http://www.iwr.usace.army.mil/

United States Bureau of Land Management (BLM)

Mission: The mission of BLM is to "sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations"

Authority: The Bureau of Land Management is responsible for managing all federal lands in the public domain. (http://www.blm.gov/wo/st/en/info/About_BLM.html). BLM was given the charge of multiple-use management by Congress, which is defined as management of public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people. There are numerous legislative acts and regulations which apply to BLM lands and can be found at http://www.blm.gov/wo/st/en/info/regulations.html.

Guiding Document: BLM Manual

BLM operates at both the federal and state levels. The following are BLM lands within the Nacimiento and San Antonio River watersheds: Redonda Mountain Sensitive Resource Area, Rocky Butte Botanical Area, Tierra Redonda, and Waterdog Creek. Any action affecting the above stated lands must be reviewed by an interdisciplinary team to determine if they are in conformance with the existing planning base, this includes all current BLM law, executive order, regulation, policy and land use plans. The NACITONE Watershed falls under the jurisdiction of the Bakersfield Field Office.

Relevant websites: http://www.blm.gov/ca/st/en/fo/bakersfield.html

United States Environmental Protection Agency (EPA)

Mission: The EPA gives the following mission statement on its website, "research, standard setting, monitoring and enforcement with regard to five environmental hazards: air and water pollution, solid waste disposal, radiation, and pesticides". Founded in 1970 as an independent agency, the Environmental Protection Agency is generally responsible for protecting human health and safeguarding the natural environment in the United States. While presiding over the entire country, the EPA also coordinates and supports research and pollution mitigation activities by state and local governments as well as private and public groups, individuals and educational institutions.

Authority: The California Environmental Protection Agency is responsible for implementing Federal Acts, such as the Clean Air Act and the Clean Water Act, that align with corresponding State Laws in an effort to streamline the agency's tasks.

Guiding Document: The Pacific Southwest's Strategic Plan (Plan) sets out the Region's goals for the next five years and describes how the EPA intends to achieve a cleaner, healthier environment.

The NACITONE Watershed lies in the US EPA's Southwest Region (Region 9). This region contains Arizona, California, Hawaii, Nevada, and the Pacific Islands and the headquarters are in San Francisco.

Relevant websites: http://www.epa.gov/region09/ and http://www.epa.gov/cfo/plan/plan.htm

United States Fish and Wildlife Service (USFWS)

Mission: The U.S. Fish and Wildlife Service is the principal federal agency for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats for the continuing benefit of the public.

Authority: The Service enforces federal wildlife protection laws such as the Endangered Species Act, and works in consultation with the Army Corps of Engineers to ensure that permitted projects protect fish and wildlife. The Service evaluates impacts and appropriate mitigations for endangered species that may be impacted by proposed projects. When protected species are involved, the Service prepares "Biological Opinions" on the project to assess the potential impacts and restrict potentially harmful activities and also is responsible for issuing any incidental take permits under the Federal Endangered Species Act. In order for an incidental take permit to be issued a habitat conservation plan is required. The issuance of these permits is contingent on the applicant obtaining a State permit.

Fish and Wildlife Service receives authority to engage applicants early in the project planning process and to make any necessary changes to the project, from the Fish and Wildlife Coordination Act, National Environmental Policy Act, and Endangered Species Act. In regards to Military Lands, the Service reviews the specific entity's management of natural resources and provides guidance on endangered species and the management of their critical habitat.

The NACITONE Watershed lies in the Service's Pacific Region (Region #1). This region headquarters is located in Portland, OR and the region contains the states of Washington, Oregon, California, Idaho, Nevada, Hawaii, and the Pacific Islands.

Relevant websites: http://www.fws.gov/pacific/ and http://www.fws.gov/policy/.

United States Forest Service (USFS)

The U.S. Department of Agriculture Forest Service is a Federal agency that manages public lands in national forests and grasslands. The agency was established by Congress in 1905 to provide quality water and timber for the Nation.

Mission: The mission of the USDA Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. The Forest Service strives to manage resources under the best combination of uses to benefit the American people while ensuring the productivity of the land and protecting the quality of the environment.

The agency accomplishes its mission through five main activities:

- Protection and management of natural resources on National Forest System lands.
- Research on all aspects of forestry, rangeland management, and forest resource utilization.
- Community assistance and cooperation with State and local governments, forest industries, and private landowners to help protect and manage non-Federal forest and associated range and watershed lands to improve conditions in rural areas.
- Achieving and supporting an effective workforce that reflects the full range of diversity of the American people.
- International assistance in formulating policy and coordinating U.S. support for the protection and sound management of the world's forest resources.

Authority: The Forest Service is responsible for managing national forests for multiple uses and benefits and for the sustained yield of renewable resources such as water, forage, wildlife, wood, and recreation.

Guiding Document: The Forest Service Directive System consists of the Forest Service Manual and Handbooks, which codify the agency's policy, practice, and procedure. The system serves as the primary basis for the internal management and control of all programs and the primary source of administrative direction to Forest Service employees.

The Forest Service is organized into National Forests in ten different regions. The NACITONE Watershed is located within Region 5, Pacific Southwest Region, Los Padres National Forest.

Relevant websites: http://www.fs.fed.us/r5/ and http://www.fs.fed.us/publications/

United States Department of Defense (DoD)

Mission: U.S. Pacific Command, in concert with other U.S. government agencies and regional military partners, promotes security and peaceful development in the Asia-Pacific region by deterring aggression, advancing regional security cooperation, responding to crises, and fighting to win.

The NACITONE watersheds are in the Pacific Command of the DoD.

Relevant websites: http://www.pacom.mil/about/mvp-statements.shtml

State Agencies

State Resources Agency

Mission: To restore, protect and manage the state's natural, historical and cultural resources for current and future generations using creative approaches and solutions based on science, collaboration and respect for all the communities and interests involved.

The Department of Fish and Game, the Department of Forestry and Fire Protection, the Department of Water Resources, and the Department of Boating and Waterways all fall under the direction of the State Resources Agency.

California Department of Fish and Game (CDFG)

Mission: The Department of Fish and Game mission is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

Authority: To meet this responsibility, the law requires any person, state or local government agency, or public utility proposing a project that may impact a river, stream, or lake to notify the CDFG before beginning the project. If the CDFG determines that the project may adversely affect fish and wildlife resources, a Lake or Streambed Alteration Agreement (1602 Agreement) is required. The principal enforcement mechanism for the CDFG is the California Fish and Game Code, Section 1602. Exclusions include projects conducted by a governmental agency and permit requirements from the Army Corps of Engineers.

The CDFG is responsible for reviewing the management of natural resources on military lands and provides guidance on federally listed species and the management of their critical habitat. The CDFG currently owns two land allotments adjacent to Camp Roberts which comprise the Big Sandy Wildlife Area which totals 865 acres. The CDFG is responsible for riparian habitats located within both watersheds and with support of USFWS adopted a no-net-loss policy for California riparian habitats.

Guiding Documents: The Fish and Game Strategic Plan emphasizes the directions CDFG needs to establish and follow to meet future challenges. It does not describe all of the things the Department currently does. The Fish and Game code identifies the agency's enforcement and regulation purview.

The NACITONE Watershed is located within CDFG's Central Region, a region that includes Fresno, Kern, Kings, Madera, Mariposa, Merced, Monterey, San Benito, San Luis Obispo, Stanislaus, Tulare and Tuolumne counties. The region's main office is located in Fresno, California and there is a local office in San Luis Obispo.

Relevant websites: http://www.dfg.ca.gov/regions/4/ , http://www.dfg.ca.gov/about/resource-mgmt.html and http://www.dfg.ca.gov/habcon/1600/

California Department of Forestry and Fire Protection (CAL FIRE)

Mission: The Department of Forestry and Fire Protection "protects the people of California from fires, responds to emergencies, and protects and enhances forest, range, and watershed values providing social, economic, and environmental benefits to rural and urban citizens" (http://www.fire.ca.gov/). A majority of the CAL FIRE workforce responds to all types of emergencies.

Authority: CAL FIRE crews and equipment are responsible for the protection of over 31 million acres of California's privately-owned wildlands. In addition, they provide emergency services of all kinds within 36 of California's 58 counties through local government contracts (http://www.fire.ca.gov/).

CAL FIRE's Resource Management Program strives to protect California's natural resources including 85 million acres that are classified as wildlands. These wildlands provide the state with timber, watershed, wildlife habitat, and recreation resources. The goal of the CAL FIRE Resource Management Program is to maintain the sustainability of all these natural resources. The Department achieves this goal by "administering state and federal forestry assistance programs for landowners, demonstrating sound management practices on eight demonstration state forests, enforcing the California Forest Practice Act on all non-federal timberlands, providing research and educational outreach to the public on forest pests, and coordinating efforts for fuel reduction to reduce the risk of fire and improve the quality of California ecosystems" (http://www.fire.ca.gov/).

Guiding Documents: The California Fire Plan is the state's road map for reducing the risk of wildfire. By placing the emphasis on what needs to be done long before a fire starts, the Fire Plan looks to reduce fire fighting costs and property losses, increase firefighter safety, and to contribute to ecosystem health.

San Luis Obispo County (CDFSLO)

The California Department of Forestry and Fire Protection has provided fire protection for the County of San Luis Obispo by cooperative agreements since 1929. Cal Fire/San Luis Obispo County 's mission is "t**o serve and safeguard the community from the impacts of fire, emergency injury and illness, and other physical dangers by providing emergency fire/ rescue response, public education, planning, and prevention for the County of San Luis Obispo and its residents".**

CDFSLO has two fire stations within the NACITONE Watershed; the Heritage Ranch Fire Station in Paso Robles and the Oak Shores Fire Station in Bradley.

Relevant websites: http://www.cdfslo.org/ and http://www.fire.ca.gov/communications/communications_factsheets.php

Department of Water Resources (DWR)

Mission: The Department of Water Resources provides dam safety and flood control services, assists local water districts in water management and conservation activities, promotes recreational opportunities, and plans for future statewide water needs. The DWR also operates and maintains the State Water Project, including the California Aqueduct. The mission of the

Division of Flood Management is to prevent loss of life and reduce property damage caused by floods, and to assist in recovery efforts following any natural disaster.

Authority: California Water Code, Sections 10004-10013.

Guiding Document: California Water Plan provides a framework for water managers, legislators, and the public to consider options and make decisions regarding California's water future. The Plan, which is updated every five years, presents basic data and information on California's water resources including water supply evaluations and assessments of agricultural, urban, and environmental water uses to quantify the gap between water supplies and uses. The Plan also identifies and evaluates existing and proposed statewide demand management and water supply augmentation programs and projects to address the State's water needs.

The NACITONE Watershed falls within two districts of the DWR: the Upper Salinas Groundwater Basin is under the San Joaquin District's jurisdiction and the Paso Robles Groundwater Basin is within the Southern Coast Jurisdiction.

Relevant websites: http://www.sjd.water.ca.gov/ and http://www.dpla.water.ca.gov/sd/index.html

Division of Safety of Dams (DSOD)

The Division of Safety of Dams was created by the State Legislature in 1929 under the California Department of Water Resources. The mission of the Division of Safety of Dams is t**o protect people against loss of life and property from dam failure. The California Water Code entrusts this regulatory power to the Department of Water Resources which delegates the program to the Division of Safety of Dams.** Division engineers and engineering geologists review and approve plans and specifications for the design of dams and oversee their construction to insure compliance with the approved plans and specifications. The dams at both the Nacimiento and San Antonio Reservoirs are inspected yearly by the DSOD. The Division of Safety of Dams main office is located in Sacramento, California and the dams at both the Nacimiento and San Antonio Reservoirs fall into the Central Region for Field Engineering.

Relevant websites: http://www.water.ca.gov/damsafety/ and http://www.water.ca.gov/damsafety/FAQuestions/index.cfm

Department of Boating and Waterways

Mission: To provide safe and convenient public access to California's waterways and leadership in promoting the public's right to safe, enjoyable, and environmentally sound recreational boating.

Authority: In 1959, the State Legislature, under authority of the Federal Boating Act of 1958, added Chapter 5 to Division 3 of the Harbors and Navigation Code. This act provided for the registration of most undocumented vessels by the State. It also established a comprehensive set of State laws and regulations governing the equipment and operation of vessels on all waters of the State. Since then the Departments responsibilities have grown.

Guiding document:

Relevant website: http://www.dbw.ca.gov/ and http://www.dbw.ca.gov/Environmental/

Regional Water Quality Control Board (RWQCB)

The Regional Water Quality Control Board is the local administrative unit of the State Water Resource Control Board.

Mission: The mission of the RWQCB is to develop and enforce water quality objectives and implementation plans that will best protect the beneficial uses of the State's waters. Each RWQCB has nine part-time Board members appointed by the Governor and confirmed by the State Senate. RWQCB's are responsible for developing "basin plans" for their hydrologic areas, governing requirements, issuance of waste discharge permits, enforcement actions against violators, and monitoring water quality.

Authority: The focus of the RWQCB is water quality; the Clean Water Act is the primary enforcement tool. The RWQCB also maintains the State's 303 d. list of impaired water bodies (section 303 d. of the Clean Water Act). When a water body is listed on the 303 d. list, regional offices prepare studies and remediation plans to bring water quality within the State's standards and to reduce the Total Maximum Daily Loads to acceptable levels.

The RWQCB becomes involved in watershed enhancement projects as part of Section 401 of the Clean Water Act. The Board works in coordination with the Army Corps of Engineers to issue compliance documents for this section of the CWA. The RWQCB has a bulk of the regulatory responsibility for the cleanup of releases from military facilities.

The RWQCB recently modified discharge permits associated with irrigated agriculture requiring landowners and farm operators to enroll in the Conditional Ag Waiver program which requires the development and implementation of a farm water quality management plan for the reduction of water quality impacts. The RWQCB is currently enrolling landowners and farm operators in the program.

The California Water Code provides regulatory guidance.

Guiding Documents: Central Coast Basin Plan

State Defined Designated Beneficial Uses for Water Quality

RWQCB Basin Plans identify the designated beneficial uses for water bodies within each hydrologic basin and the water quality objectives (stated as physical and/or chemical parameters) to be achieved or maintained to protect each beneficial use. Beneficial uses for a particular water-body include municipal, agricultural and industrial supply, power generation, recreation, aesthetic enjoyment, navigation and preservation, and enhancement of fish, wildlife and other aquatic resources.

The Central Coast Region Water Quality Plan (Basin Plan), adopted by the Regional Water Quality Control Board (RWQCB) in 1989 and approved by the state board in 1990, defines beneficial uses for water bodies in the Central Coast, defines water quality objectives to protect these uses, and outlines implementation and monitoring plans. Amendments to the Basin Plan were approved by the RWQCB on February 11, 1994 and September 8, 1994.

The state defines pollution as impairment to beneficial uses in terms of the physical, chemical, or biological characteristics of water. There is also an "anti-degradation" directive in both state and federal law. EPA requires a biennial water quality assessment that describes the level to

which a water body can support its designated beneficial uses: fully supporting, fully supporting but threatened, partially supporting and not supporting (Range Water Quality Management Plan 1995).

When activities occur that adversely impact water quality and a beneficial use is no longer being supported, remediation actions may occur to restore beneficial uses. One way to approach goals and strategy development is to consider what actions could be planned to preserve or restore impacted beneficial uses. Those actions could be configured into a strategy to preserve/ restore beneficial uses. The Regional Water Quality Control Board has also removed designated beneficial uses for particular water bodies. This happens in rare instances when it is determined that the beneficial use is no longer appropriate for that water body.

The Central Coast Basin Plan provides a list of designated beneficial uses for many of the water bodies in these two watersheds.

None of the rivers in the watershed have beneficial use designations of aquaculture (AQUA), estuarine habitat (EST), marine habitat (MAR), inland saline water habitat (SAL), preservation of biological habitats of special significance (BIOL), shellfish harvesting (SHELL) or areas of special biological significance (ASBS).

Relevant websites: http://www.swrcb.ca.gov/rwqcb3/index.htm and http://www.swrcb.ca.gov/rwqcb3/WMI/Index.htm

Office of Environmental Health Hazard Assessment (Cal/EPA)

Mission: To protect and enhance public health and the environment by scientific evaluation of risks posed by hazardous substances.

Authority: The Department is responsible for developing and providing risk managers in state and local government agencies with toxicological and medical information relevant to decisions involving public health.

Guiding Document: OEHHA's Strategic Plan
Relevant websites: http://oehha.ca.gov/about/description.html and http://oehha.ca.gov/fish.html

California National Guard

Mission: The California Army National Guard organizes, trains, equips, and resources community based land forces. On order, mobilizes to support state and/or federal authority.

Authority:

Guiding Document: California National Guard Strategic Plan

Relevant websites: http://www.calguard.ca.gov/Pages/default.aspx

Local Agencies

The primary local resource agencies related to watersheds jurisdiction are included. In addition, the following local agencies may be involved in the protection of water quality and watershed health but are not further described in this section: county agriculture commissioner offices, county health departments, cooperative extensions and law enforcement agencies and departments.

Monterey County Parks Department

Mission: The Monterey County Parks Department maintains stewardship over a system of county parks. These outdoor recreation resources are managed to preserve, promote, and interpret the natural, historical, and cultural values of Monterey County. They are operated to provide opportunities for the public's enjoyment, inspiration, education, personal development and cultural enrichment.

Relevant websites: http://www.co.monterey.ca.us/parks/nacimiento.html and http://www.co.monterey.ca.us/parks/sanantonio.html

Monterey County Resource Management Agency - Planning and Building Services Departments

Mission: The Mission of the Resource Management Agency – Planning and Building Services Department is to efficiently process planning permits, provide quality long-range planning and consistently develop and administer land use policies.

Authority: California state law requires each city and county to adopt "a comprehensive, long-term general plan for the physical development of the county or city, and any land outside its boundaries which bears relation to its planning" (Government Code section 65300).

Guiding Document: Monterey County's General Plan identifies standards and programs for the development of unincorporated areas.

A majority of the NACITONE watershed falls within the South County Planning Area which has its own set of development standards and regulations with the South County Area Plan. Lands surrounding the San Antonio Reservoir are designated within the Monterey County General Plan as Public/Quasi-public and Rural Grazing, with smaller surrounding areas designated as Farmlands and Permanent Grazing. A small area north of the San Antonio Reservoir is designated for Rural Residential use with a minimum of 5 acres per unit. The NACITONE Watershed is partially located in unincorporated Monterey County.

General Plan (2006)

The General Plan is currently being updated.

Relevant websites: http://www.co.monterey.ca.us/rma/services.htm and http://www.co.monterey.ca.us/planning/gpu/draftNov2007/default.htm

County of San Luis Obispo, Planning and Building Department

Mission: The Planning and Building Departments mission is 'promoting the wise use of land helping to build great communities.'

Authority: California state law requires each city and county to adopt "a comprehensive, long-term general plan for the physical development of the county or city, and any land outside its boundaries which bears relation to its planning" (Government Code section 65300).

Guiding Document: The San Luis Obispo County General Plan expresses the county's development goals and embodies public policy relative to the distribution of future land uses. It identifies county's land use, circulation, environmental, economic, and social goals and policies as they relate to land use and development.

Part of the NACITONE Watershed is located within unincorporated San Luis Obispo County, and falls within the area covered by the Nacimiento Area Plan. The County's General Plan identifies standards and programs for the development of unincorporated areas and the Nacimiento Area Plan provides specific development regulations for the area. Lands surrounding Nacimiento Reservoir are for the most part designated as Agricultural and Open Space within the SLO County General Plan. Land uses adjacent to the reservoir primarily include Rural Residential, Recreation, Agriculture, and Open Space, with some Residential Suburban.

Conservation Element

This element is in the process of an update initiated in 2006. There is an existing Conservation Element included in the "Environment Plan" from 1974. The draft plan is scheduled to be released in October 2008 with Planning Commission hearings in February 2009 and Board of Supervisors hearings in August 2009.

Relevant websites: http://www.slocounty.ca.gov/planning.htm and http://www.slocounty.ca.gov/planning/General_Plan__Ordinances_and_Elements.htm

County of San Luis Obispo, Public Works and Transportation Department

Provides public services related to the safe and efficient movement of traffic on the 1,310 miles of County maintained roadways; engineering and surveying review of proposed land development; administration and operation of various water and waste water wholesale and retail facilities, including the Nacimiento Water Supply and Los Osos Waste Water Projects; long term master water planning; franchise administration for the unincorporated areas. The Public Works Department is also responsible for managing the County's Storm Water Management Program. The San Luis Obispo County Water Quality Laboratory is part of the Utilities Division of the Public Works Department.

Relevant websites: Website for SLO Co. PWD: http://www.slocounty.ca.gov/PW.htm
Website for Nacimiento Water Project: http://www.slocounty.ca.gov/PW/NacWP.htm

B. Legal regulatory Framework

California Environmental Quality Act (CEQA) is the foundation of environmental law in California; it strives to protect all aspects of the environment through thorough analysis. CEQA requires state and local agencies to prepare Environmental Impact Reports for most projects. These reports are then analyzed and used to make decisions about the severity of the impacts on the environment. CEQA also requires that mitigation measures are identified for all impacts. If an action is identified as a project an Initial Study is required, after analysis of the initial study occurs the decision is made to either make a Negative Declaration of environmental impacts or to prepare an Environmental Impact Report. If impacts are found mitigation measures and project alternatives must be discussed. The responsible agency can decide to go forward with a project despite environmental impacts with a Statement of Overriding Consideration, which explains why the benefits of a project outweigh the environmental impacts.

National Environmental Protection Act (NEPA) is the federal law that requires all federal agencies to prepare Environmental Impact Statements for actions that have a significant impact on the environment. NEPA is also a model for several policies at the state level, including CEQA. Environmental Impact Statements are very similar to EIRs and require that any environmental impacts be identified as well as creating mitigation measures to address the impacts.

Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water or with water quantity issues.) The statute employs a variety of regulatory and non-regulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.

The Porter-Cologne Water Quality Control Act establishes the State Water Resources Control Board and each Regional Water Quality Control Board as the principal State agencies for having primary responsibility in coordinating and controlling water quality in California.

C. Resources Agencies - Non-Regulatory Entities

Non-regulatory entities can operate on the Federal, State and Local levels and are designed to perform necessary functions that do not involve direct policy. These entities do not enforce laws. Their focus is generally on education, voluntary landowner participation, and landowner assistance.

Federal Agencies

National Oceanic and Atmospheric Administration (NOAA) Restoration Center

The National Oceanic and Atmospheric Administration perform many non-regulatory tasks through its Restoration Center which plans, implements, and funds coastal restoration projects throughout the United States.

Mission: The NOAA's website identifies that the Restoration Center's mission is to "enhance living marine resources to benefit the nation's fisheries by restoring their habitats". The NOAA Restoration Center accomplishes its mission by restoring degraded habitats, advancing the science of coastal habitat restoration, transferring restoration technology to the private sector, the public and other government agencies and by fostering habitat stewardship and conservation ethics.

Three primary programs allow the Restoration Center to restore fisheries habitat. The first is the Community-based Restoration Program which takes a grass-roots approach to restoration and engages communities to participate in hands-on local habitat restoration projects. The second program is the Damage Assessment Remediation and Restoration Program, which brings in scientists and managers after oil spills, toxic releases, or ship groundings to restore injured marine resources. The Restoration Research Program works to advance new science and technology within the restoration field.

Relevant websites: http://www.nmfs.noaa.gov/habitat/restoration/

Natural Resources Conservation Service (NRCS)

Originally called the Soil Conservation Service, the Natural Resources Conservation Service was established in 1935 and has provided leadership in a partnership effort to help America's private land owners and managers conserve their soil, water, and other natural resources.

Mission: The NRCS has six mission goals: high quality and productive soils, clean and abundant water, healthy plant and animal communities, clean air, adequate energy supply, and working farms and ranchlands. In order to achieve these goals, the NRCS implements the following strategies:

- Cooperative conservation: seeking and promoting cooperative efforts to achieve conservation goals.
- Watershed approach: providing information and assistance to encourage and enable locally-led, watershed-scale conservation.
- Market-based approach: facilitating the growth of market-based opportunities that encourage the private sector to invest in conservation on private lands.

Service offices serving the Nacitone watersheds are located in Templeton and Salinas.

Relevant websites: http://www.ca.nrcs.usda.gov/

United States Fish and Wildlife Service (USFWS) Partners for Fish and Wildlife Program

The United States Fish and Wildlife Service participates in a cooperative conservation program called Partners in Wildlife.

Mission: The Program's mission is to efficiently achieve voluntary habitat restoration on private lands, through financial and technical assistance, for the benefit of Federal Trust Species. The USFWS's website lists the program's four main objectives: Promote and implement habitat improvement projects that benefit Federal Trust Species, Provide conservation leadership and promote partnerships, Encourage public understanding and participation, Work with U.S. Department of Agriculture to implement conservation programs. The Partners program has locally based field biologists who work directly with private landowners and other partners to plan implement and monitor their projects in an environmentally friendly manner.

Relevant websites: http://www.fws.gov/partners/

Local Agencies and Organizations

Cal-Shasta Club

Cal-Shasta Club is a private recreation club consisting of 120 members, located on 340 acres, situated along the southern shoreline of Nacimiento Reservoir. Amenities consist of approximately 6 miles of private roads, launch ramp, helicopter pad (day and night), ice machines, clubhouse, a park and BBQ facility.

Relevant websites: http://lakenacimientosouthshorearea.com/Cal-Shasta.htm

Heritage Ranch Community Service District

Mission: The purpose and mission of Heritage Ranch CSD is to provide municipal services to the Village of Heritage Ranch in a manner that is efficient, safe and in accordance with applicable law. These services include the supply of drinking water, the disposal of wastewater, removal of solid waste, parks and recreation and retail gasoline.

The Heritage Ranch CSD is responsible for the operation and maintenance of the Heritage Ranch sewer and for allocating the 1100 acre feet per year allotment from the Nacimiento Reservoir for the Community of Heritage Ranch. The District's service area includes 5,361 acres; the Heritage Ranch CSD is bounded on the west by Nacimiento Reservoir, on the north by Nacimiento River, on the east by Camp Roberts, and on the south by certificated parcels. The Heritage Ranch CSD is located in Paso Robles, within the Community of Heritage Ranch.

Relevant websites: http://www.heritageranchcsd.com/

Home Owner's Associations

Heritage Ranch Owner's Association

The Heritage Ranch Owner's Association is responsible for managing 9,150 acres of land including 2,104 single-family residential lots and 5,100 acres of open space. Heritage Ranch is located along the southern shoreline of the Nacimiento Reservoir.

Relevant websites: http://hroa.us/main.htm

Oak Shores Community Association

The Oak Shores Community Association is responsible for the management of the Oak Shores Community and its facilities, which include a marina, clubhouse, boat slips and campground. The Association consists of five committees, Finance, Recreation, Architectural Review, Oak Leaves and Private Docks. The Finance Committee creates an annual operating budget for the community. The Oak Shores Community Association is managed by a Board of Directors, but also employs staff to carry out general management, business operations, code enforcement and maintenance.

Relevant websites: http://oakshores.us/

Santa Lucia Cabinowners Association

The Santa Lucia Cabinowners are a tract of recreational residences within the Los Padres National Forest and the upper San Antonio and Arroyo Seco River watersheds. They are sanctioned by the National Forest Homeowners Association.

Laguna Vista Boat Club

Laguna Vista Boat Club is located on the north shore of Nacimiento Reservoir at the end of Bee Rock Road. The club was established in 1964 and has 21 members on 10 acres. The members share a common area referred to as "The Point".

Lake Recreation and Public Safety Roundtable

The Lake Recreation and Public Safety Roundtable is an informal group of representatives from communities around Nacimiento Reservoir that meets with Monterey County Park Rangers to discuss issues of common concern to the Rangers and communities around the reservoir. The group works together to provide communication and support to goals and initiatives of Monterey County and the various private organizations.

Monterey County Farm Bureau

Monterey County Farm Bureau is a private, nonprofit association of farmers and ranchers throughout Monterey County. The Farm Bureau serves as a collective voice for farmers and ranchers and provides information, benefits and services. Farm Bureau cooperates with other agricultural organizations to fulfill its purpose of working for the solutions to the problems of the farm, the farm home and the rural community.

Relevant website: http://www.montereycountyfarmbureau.org/

Monterey County Water Resources Agency (MCWRA)

Mission: The Monterey County Water Resources Agency manages, protects and enhances the quantity and quality of water and provides specified flood control for present and future generations of Monterey County.

Specific information regarding reservoirs, precipitation, stream flow and groundwater are provided on the MCWRA website, or can be found at the office located in Salinas. The MCWRA carries out all County of Monterey Flood Control and Water Conservation District actions.

Relevant websites: http://www.mcwra.co.monterey.ca.us/

Nacimiento Regional Water Management Advisory Committee (NRWMAC)

NRWMAC represents visitors, property owners and enthusiasts of all sorts that enjoy Nacimiento Reservoir. NRWMAC acts as the collective voice of reservoir area property owners at the Monterey County Reservoir Operations Committee meetings held monthly in Salinas. This is where decisions are made which control the outflow of water from the reservoir. NRWMAC's goal is to maximize the water level in Nacimiento Reservoir from May 1st through October 1st.

Ranchos Del Lago

Ranchos Del Lago is an area of 21 privately owned parcels ranging in size from 7 to 268 acres. The parcels are located on the south side of Nacimiento Reservoir. Amenities include a community launch ramp.

Resource Conservation District of Monterey County (RCDMC)

Resource Conservation Districts are organized under the California Public Resources Code. The Monterey Resource Conservation Districts located within the Central Coast Region and is responsible for carrying out natural resource conservation programs within its boundaries, which cover 2,141,430 acres.

Mission: The mission of the RCDMC is to conserve and improve natural resources, integrating the demand for environmental quality with the needs of agricultural and urban users. The Monterey Resource Conservation District provides direct assistance to Monterey County farmers and landowners to protect soil, water, and natural habitats. The RCDMC mainly does public education work but also provides technical assistance to land users, schools, groups, organizations and the general public in conjunction with the Natural Resources Conservation Service. The RCDMC also partners with agricultural and natural resource protection organizations and agencies throughout the Central Coast.

Relevant websites: http://www.rcdmonterey.org/

Running Deer Ranch

Running Deer Ranch is an area on the south side of Nacimiento Reservoir in the area of Frankln and Las Tablas creeks. The Ranch consists of 138 property owners. Parcels range in size from 3 to 40 acres. The owners have a common area called "The Point" where they have a picnic area and boat launch ramp.

San Luis Obispo County Water Resources Advisory Committee

Mission: The San Luis Obispo County Water Resources Advisory Committee's purpose is to advise the County Board of Supervisors concerning all water resources policy decisions of the San Luis Obispo County Flood Control and Water Conservation District.

The Committee is also responsible for making recommendations for specific water resource programs and methods of financing these programs to the Board of Supervisors. The Committee includes members from the County at Large, every City in San Luis Obispo County, every local Community Service District, Resource Conservation Districts, Agriculture and the County Farm Bureau, Environmental representatives, and Water Agencies and Institutions. The committee meets once a month in San Luis Obispo.

Relevant websites: http://www.slocountywater.org/site/Water%20Resources/Advisory%20Committee/index.htm

San Luis Obispo County Farm Bureau

The San Luis Obispo County Farm Bureau is a non-governmental, non-profit, voluntary membership corporation that's purpose is to protect and promote agricultural interests throughout San Luis Obispo County and to find solutions to the problems of the farm, the farm home and the rural community. Farm Bureau strives to protect and improve the ability of farmers and ranchers engaged in production agriculture to provide a reliable supply of food and fiber through responsible stewardship of California's resources.

Relevant website:
http://www.slofarmbureau.org/About-Us/About-Us.htm

South Nacimiento Road Association (SNRA)

The South Nacimiento Road Association represents more than 500 property owners who maintain approximately 11 miles of private roads that come from Chimney Rock road along the shore of Nacimiento Reservoir. This area covers approximately 8000 acres.

Relevant websites: http://lakenacimientosouthshorearea.com/SNRA%20ROAD%20REPAIR%20PRIORITY%20LIST%202008%20REV2.13.08.pdf

South Shore Village Vacation Club

South Shore Village Vacation Club is located on the south shore of Nacimiento Reservoir at the west end of the reservoir in an area often referred to as "The Narrows". The club owns approximately 560 acres, and has 40 members. Amenities include consist of launch ramps, bathroom facilities, ice machines, and a daytime heliport.

Tri-Counties Boat Club

Tri-Counties Boat Club is located on the south side of Nacimiento Reservoir in the Las Tablas bay area. The Club owns 40 acres and has 86 members. Facilities include a BBQ area and boat launch ramp.

Upper Salinas Las Tablas Resource Conservation District

Resource Conservation Districts are organized under the California Public Resources Code. The Upper Salinas Las Tablas Resource Conservation District is responsible for carrying out natural resource conservation programs within its boundaries, which covers approximately 1.5 million acres of the Central Coast area of California, extending from southeastern Monterey County to northwestern, central, and eastern San Luis Obispo County. About 700,000 acres are grazing lands and 400,000 are cropland; livestock production and dry farmed grains and hay are the major income producers for large landowners. The district includes 1,365,000 acres in San Luis Obispo County (about three-quarters of the county area) and 138,000 acres within Monterey County. The largest landowners are the federal government (Forest Service, BLM and U.S. Army (Camp Roberts), Hearst Corporation (Hearst Ranch and the Jack Ranch: *not located within the NACITONE Watershed*), and the Monterey County Water Resources Agency (Nacimiento Reservoir and the lands surrounding the reservoir).

In addition, the US-LT RCD has some purview over grading permits in the watersheds inside San Luis Obispo County plus the areas of Camp Roberts and Parkfield in Monterey County. Under the Alternative Review Program, landowners that neglected to obtain a County grading permit are referred to the RCD. The landowner can apply for an ARP grading permit or be referred back to the San Luis Obispo County Code Enforcement and District Attorney's Office. The Erosion Control Assistants Program, available to all landowners in San Luis Obispo County voluntarily, also connects to Code Enforcement and /or the District Attorney similar to the ARP. These alternative options for grading and erosion control enforcement provide with a second chance to meet permitting requirements and ensure that Best Management Practices are implemented.

Guiding Document: Upper Salinas Watershed Action Plan, Annual Plan and Long Range Plan

Relevant websites: http://www.us-ltrcd.org/ and http://www.mcwra.co.monterey.ca.us/Agency_data/USLS%20RCD%20Watershed%20Action%20Plan/USLS%20RCD%20Watershed%20Action%20Plan.htm

D. Relationship to Other existing Plans

The NACITONE Watersheds Management Plan is a non-regulatory document. This section reviews regulatory and non-regulatory plans that focus on or include these watersheds. Recommendations of the NACITONE Plan attempt to complement these existing plans where there is relevance to issues identified for these watersheds.

Central Coast Region Basin Plan (1994)
California Regional Water Quality Control Board

The goal of the Central Coast Region Basin Plan is to show how the quality of the surface and ground waters in the Central Coast Region should be managed to provide the highest water quality reasonably possible. The plan lists the various water uses and describes the water quality level that must be maintained to allow those uses. The Regional Board implements the Basin Plan by issuing and enforcing waste discharge requirements to individuals, communities, or businesses whose waste discharges can affect water quality. The Basin Plan is implemented by encouraging water users to improve the quality of their water supplies. Public works or other projects that affect water quality are reviewed and their impacts identified. The Central Coast Regional Board has jurisdiction over a 300-mile long by 40-mile wide section of California's central coast. Its geographic area encompasses all of Santa Cruz, San Benito, Monterey, San Luis Obispo, and Santa Barbara Counties.

Central Coast Regional Water Quality Control Board Vision (2008)

The Central Coast Regional Water Quality Control Board is moving in a fundamentally new strategic direction, based upon a Vision of Healthy Functioning Watersheds. This new Vision represents a refocusing of their approach providing a new framework for how they conduct business and achieve measurable results. The Vision structures their work towards their highest water quality priorities and more strategically aligns them with the anticipated challenges and opportunities in water quality and positions the agency to respond more nimbly to unexpected ones. For more information visit:
http://www.waterboards.ca.gov/centralcoast/publications_forms/publications/vision/index.shtml

Nacimiento Area Plan, San Luis Obispo County (2003)

The Nacimiento Area Plan is a supplemental plan to the County's General Plan. The plan deals specifically with 97,665 acres that comprise the planning area which is adjacent to the Monterey County line to the North, the Adelaida planning area to the South, Camp Roberts to the East and the Santa Lucia Range to the West. Nacimiento Reservoir is the center of the planning area. This plan describes County land use policies for the Nacimiento Planning Area, including regulations which are also adopted as part of the Land Use Ordinance.

Water Supply Programs (WSP-14, 15, 16, 17)
The Plan identifies issues related to water supply, the first refers to reservoir water use and the need to identify properties illegally taking water directly from the reservoir and removing all equipment used for this purpose. The second addresses the possibility of using reclaimed water and returning it to the reservoir to allow "equivalent amounts of water to be taken from reservoir supplies" (p.3-10). The last issue deals specifically with Oak Shores and Heritage Ranch, "if total water use reaches 1,100 acre feet per year, a moratorium should be placed on further development within the affected project"(p.3-10).

Rural Area Programs
The following programs apply to portions of the Nacimiento Planning Area outside of village reserve lines, in the land use categories listed.

Areawide (RAP-1)
The Plan states that the county should continue to encourage owners of eligible lands to participate in the agricultural preserve program.

Open Space (RAP-2)
The Plan states that the County will work with Monterey County Flood Control and Water Conservation District to create plans "for a wilderness park with appropriate passive recreational uses" (p.6-13).

Village Programs
The following program applies to all land use categories within the Heritage and Oak Shores village reserve lines.

Phasing Plans (VP-1)
The Plan states that the County will work with developers and Monterey County to update current project phasing plans and will include them within the Land Use Element.

Combining Designations
The Plan refers to combining Designations as "special overlay land use categories applied in areas of the county with potentially hazardous conditions or special resources, where more detailed project review is needed to avoid or minimize adverse environmental impacts, or effects of hazardous conditions on proposed projects" (p.7-1).

The Santa Lucia Range and Foothill Areas
For the Village portion of the Planning Area the combined designation refers to those lands having moderately high and high landslide risk potential. The designation only refers to areas with high landslide risk that are located within the Rural portion of the Planning Area.

Nacimiento River and Canyon; Dip, Franklin, Las Tablas, Snake and Town Creeks; and Lake Nacimiento

This designation refers to water courses that are "identified as having potential flood hazards and development proposals must incorporate mitigation measures" (p.7-1). Specifically for Nacimiento Reservoir, "the 800 foot elevation constitutes the lake's high water level and no habitable structures are permitted below the 825 foot elevation" (p.7-1).

Tierra Redonda Mountain
This mountain is a major area landmark and is under Bureau of Land Management ownership. The mountain is considered to have high preservation priority by the State Department of Parks and Recreation and is of ecological importance. The mountain is considered to be public land and preservation of the entire mountain is the best strategy for conserving the ecosystem.

Lake Nacimiento Drive-Interlake Road
This road has been adopted as a State scenic highway route from Chimney Rock Road northwest to the Monterey County line; all visual impacts in this area should be minimized.

Rocky Butte Botanical Area
The Plan identifies this area as having botanical and scenic value. The Bureau of Land Management owns approximately 460 acres of this area, the remaining acres are privately owned and the County will encourage open space easements for these portions.

In addition, the following apply to specific Land Use Ordinances for the Nacimiento Area Plan:

Section 22.102.040

Site planning and development standards
Proposed development shall be designed and constructed in compliance with the following standards.

Snake and Dip Creeks**.** Retain Snake and Dip Creeks in their natural state, except for stock ponds and low intensity recreational uses such as trails and picnic areas.

Vegetation Protection**.** Site new development to avoid areas of dense brush and oak woodland vegetation.

Section 22.102.060

Protection of native vegetation**.** New parcels and development shall be sited where possible to avoid areas of dense brush and oak woodland vegetation, and locate building sites along ridges or hilltops where development would not be silhouetted against the sky, as seen from existing and proposed collector and arterial streets.

San Luis Obispo Integrated Regional Water Management Plan (2005) San Luis Obispo County

The San Luis Obispo Integrated Regional Water Management Plan identifies five water management planning objectives which include water supply, water quality protection and improvement, ecosystem preservation and restoration, groundwater monitoring and management and flood management. The Nacitone watersheds fall in the Salinas and Nacimiento Water Planning Areas.

The Nacitone Watershed Management Plan will aid in meeting the objectives and regional solutions defined in the IRWMP (Section H3). Related objectives include to "protect and improve source water quality" and "protect and improve groundwater quality from point and nonpoint source pollution, including nitrate contamination; MTBE and other industrial, agricultural, and commercial sources of contamination; naturally occurring mineralization, boron, radionuclide, geothermal contamination; and seawater intrusion and salts." In addition, the IRWMP states that "projects recommended in sub-regional plans have already been coordinated at the sub-regional level and can be considered excellent candidates for implementation of the IRWMP" (Section M1.3). The Regional Priorities section provides a process for modifying priorities in response to change. It is anticipated that the Nacitone Plan, as a local watershed planning document, will be incorporated into the IRWMP using the adaptive management strategy (Section F4).

Nacitone Watershed Management Plan Issues	Salinas Valley Integrated Regional Water Management Plan Categories	San Luis Obispo Integrated Regional Water Management Plan Categories
1. Recreation 2. Gaps in Knowledge: Monitoring and Information Needs 3. Preventing Pollution from Point and Nonpoint Sources 4. The Role of Agriculture 5. Fire in the Watersheds 6. Taking Enforcement Action 7. Communication & Coordination 8. Watershed Health: Plants & Animals 9. Roads and Culverts 10. Education and Outreach 11. Invasive Species	1. Water Supply 2. Water Quality 3. Flood Protection 4. Environmental Enhancement	1. Water Quality 2. Water Supply 3. Ecosystem Preservation and Restoration 4. Groundwater Monitoring and Management 5. Flood Management

Figure 47. Comparison of issues addressed in the Nacitone WMP to the categories covered in the SV IRWMP and the SLO IRWMP

Salinas Valley Integrated Regional Water Management Plan (2006) Monterey County Water Resource Agency

The Salinas Valley IRWMP provides goals and objectives that address water supply, water quality, and other environmental issues at a regional scale. The planning area is defined by the Salinas Valley Groundwater Basin and describes a Long Term Regional Priority (Section 6.3.4) to implement integrated watershed management in the Nacimiento and San Antonio River watersheds in order to improve the water quality in the reservoirs as well as the riparian habitat and aquatic ecosystems of the Salinas River and the Salinas River Groundwater Basin. The Nacitone Plan will provide the essential local level of knowledge, planning and project prioritization to assist MCWRA in meeting this long term priority.

South County Area Plan, Monterey County (2007)

The South County Area Plan supersedes the General Plan for the South County Area. The plan consists of 1,281 square miles of the southernmost section of Monterey County. The area is bordered by the Central Salinas Valley Planning Area to the North, the San Benito, Fresno and Kings County lines to the East, the Coast Planning Area makes up the western border and the San Luis Obispo County line is the Southern boundary.

Land Use (SC-1.2, 1.3)
The Plan encourages clustered development in order to preserve agricultural land and open space and to make the most efficient use of land; and any policy or program (including large lot zoning and agricultural land trusts) that enhance the competitive capabilities of farms and ranches.

Safety (SC-4.1)
The Plan requires that any channelization or realignment work on the Salinas River may not be permitted unless an assessment by the Monterey County Water Resources Agency is done to ensure that the work will not increase flood hazards downstream.

Public Services (SC-5.2, 5.3, 5.5, 5.6)
The South County Area Plan will strive to protect and preserve natural and artificial groundwater recharge areas, water quality, natural resources, soils and watersheds. All New Development shall not occur on or in close proximity to the main channels and associated floodways of the Nacimiento, San Antonio, and Salinas Rivers. The Plan states that all commercial recreation facilities for camping and boating shall be compatible with surrounding uses, of moderate size, and consistent with all resource protection and hazard avoidance policies. The County also hopes to establish a park site along the Salinas River at Camp Roberts.

Stormwater Management Program - National Pollution Discharge Elimination System (NPDES)
San Luis Obispo County

The County Stormwater Management Program encompasses the designated unincorporated urbanized areas of San Luis Obispo County. The program complies with all of the US Environmental Protection Agency, National Pollutant Discharge Elimination System Phase II Final Rule and State Water Resources Control Board "Waste Discharge Requirements for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems". This program was developed to reduce stormwater pollutants to receiving waters to the maximum extent practicable through the use of Best Management Practices.

Relevant website: http://www.slocounty.ca.gov/PW/Stormwater/SWMP.htm

Existing Management Objectives of Military Installations and the United States Forest Service

The United States Army at the Fort Hunter Liggett training base, the National Guard at Camp Roberts, and the US Forest Service, Monterey District at Los Padres National Forest are important watershed partners for the Nacitone Steering Committee and any future efforts that might arise from this Watersheds Management Plan. The public lands entrusted to those three entities represent approximately 48.1% of the combined San Antonio and Nacimiento Rivers watersheds.

In the Fort Hunter Liggett April 2007 amended Integrated Natural Resources Management Plan (INRMP, 2007) an ecosystem management philosophy is set forth.

> *In accordance with that philosophy, FHL is developing partnerships with various agencies to support management of its natural resources. Major partners in implementing this plan (INRMP 2007) are the USFWS and the CDFG. Other partners include other Department of Defense agencies, other Federal and State agencies, universities, contractors, and private citizens. An emphasis of the INRMP is to strengthen existing partnerships and to identify and develop new partnerships (INRMP, 2007, pg.5).*

The development and strengthening of partnerships with all the parties noted in the above paragraph was also a strong emphasis of the Nacitone Steering Committee across all issue areas identified in the *Watershed Strategy.* A representative from the Fort Hunter Liggett Environmental Division participated with the Steering Committee and Technical Advisory Committee. Camp Roberts staff met with the Nacitone Facilitator and was also an early partner

with the MCWRA in preparing the grant proposal for the watersheds management plan. US Forest Service, Monterey District staff contributed to several Steering Committee meetings, provided background information and helped review sections of the *Watershed Strategy.*

Nexus with the Nacitone Watershed Strategy:

Environmental documents from the two military installations and the US Forest Service contain goals that are similar to those in the *Watershed Strategy* as well as identify opportunities for additional data collection.

For example, the military Land Condition Trend Analysis (LCTA) process for both military installations could be useful in tracking long-term trends in the watershed. LCTA was initiated in the mid-1980s by the Department of Army for uniform data collection. LCTA collects physical and biological resources data to relate land conditions to training activities. These data are intended to provide information to effectively manage land use and natural resources.

Below are six, selected issues from the Fort Hunter Liggett INRMP, 2007 with goals that are very similar to those in the *Watershed Strategy* thereby presenting opportunities for collaboration to achieve common goals.

Selected Issues, Goals, and Actions from the Fort Hunter Liggett INRMP, 2007 (pages 159-184)

WATER QUALITY - Issue: Although water quality is high in both major river drainages, the potential for point source and nonpoint source contamination from sedimentation and nutrients exists. Goal: Maintain high quality surface waters to support viable populations of aquatic and terrestrial life.
Actions
1. Continue to implement the storm-water pollution prevention plan (Radian Corporation 1995).
2. Maintain vegetation in watersheds and at reservoirs to promote natural filtering of sediments.
3. Continue to monitor surface water quality. Collect total suspended solids data from the San
Antonio River at Nacimiento Road and at Sam Jones Road for determination of overall impacts of Cantonment area use stations on tributary streams to better pinpoint sources of suspected sediment loadings.
4. Continue groundwater monitoring that includes drinking water monitoring and monitoring for suspected pollution sources.
5. Continue reservoir and initiate river water chemistry data collection (dissolved oxygen, pH, temperature, and nitrates).

OAK WOODLANDS - Issue: Recruitment of mature oak trees is poor throughout California and will eventually result in the loss of the mature component of the oak population.
Goal: Maintain and enhance mature oak woodland stands and enhance oak woodland seedling regeneration.
Actions
1. Minimize oak loss resulting from mechanical removal and controlled burns.
2. Continue study to determine effects of different fire regimes on mature valley oak trees.
3. Continue FHL Training Regulation 350-2 restrictions that protect oak woodlands.

4. Use existing GIS data to develop large-scale management units by classifying areas by dominant vegetation (e.g., valley oak savanna, blue oak woodland). Within these, identify locations most frequently used for military training, annual burn sites, potential future grazing sites, and endangered species habitats.
5. Identify management and monitoring requirements in the management units, such as exotic species control, propagating and replanting oaks, and assessing effects of frequent fire.
6. Identify the status of stands in management units, such as recruitment occurrence, stand density, and health of trees in the stand.
7. Identify areas where oaks historically occurred that might support restored oak stands.
8. Identify areas where oak recruitment is most likely to be successful and focus efforts at those locations.
9. Continue to collect acorns from FHL; propagate acorns; and use these for replanting efforts on FHL.

NATIVE BUNCH GRASSLANDS
Issue: Most native bunchgrasses have been replaced with less desirable exotic annual species of grasses. Goal: Maintain and promote widespread and diverse native bunchgrass grasslands.
Actions
1. Continue reseeding projects by the LRAM (Land Rehabilitation and Maintenance) program using a mixture of native grass seeds.
2. Investigate the potential for livestock grazing and fire to be used in promoting and enhancing native bunchgrasslands.

RARE NATURAL COMMUNITIES - Issue: CNDDB rare natural communities occurring on FHL include sycamore alluvial woodland, valley needlegrass grassland, and valley oak woodland. FHL should ensure that they remain viable and intact components of the FHL ecosystem. Goal: Protect rare natural communities through measures described for individual vegetation communities.
Action - Continue to implement protective measures described for individual vegetation communities.

FIRE - Issue: Wildland fire is a relatively common event that affects the landscape of FHL. The effects of wildland and prescribed fire on natural resources are not well documented or understood. Goal: Assess the impact of fire on species of interest, vegetation communities, and animal and plant populations of interest.
Actions
1. Evaluate fire history and species information with GIS
Goal: Use fire as a tool to achieve natural resource management and training goals and objectives.
2. Use prescribed fire to manipulate vegetation to achieve natural resource and training goals and objectives.
3. Coordinate with Directorate of Fire Services of prescribed burns through environmental review.
4. Complete and implement the Wildland Fire Management Plan.

GRAZING - Issue: Livestock grazing was terminated on FHL in 1991 due to excessive forage utilization and unacceptable resource damage associated with poor livestock management and drought. Goal: Evaluate the possibility of developing a grazing program that promotes biological diversity, provides minimum impact to the military mission, is

tailored to the native flora and fauna of FHL, does not conflict with Endangered Species Act compliance, and protects and maintains cultural resources.
Actions
1. Develop a livestock grazing options that are consistent with the goal.
2. Complete an environmental assessment to determine whether the grazing program should be reinitiated.
3. Implement the grazing management plan option selected.
(INRMP, 2007 – Fort Hunter Liggett).

Camp Roberts has developed Land Rehabilitation and Maintenance (LRAM) goals and objectives and an Environmental Awareness program that could be assessed for possible collaborative opportunities with the Nacitone Watersheds Management Plan. Below are two of the goals listed for *Riparian Ecosystem Management and River, Pond and Reservoir Ecosystem Management in the Camp Roberts* INRMP, 2000.

GOAL: Protect and enhance riparian habitats to ensure healthy, functioning systems.

GOAL: Protect and maintain aquatic ecosystems in accordance with state and federal laws and regulations and adhering to the principles of ecosystem management for the purposes of a training resource and each river's designated beneficial uses.

The U.S. Forest Service, Monterey District staff are key partners for a future Nacitone community group to identify shared goals for these watersheds. There is a *Land Management Plan,* prepared in September 2005, covering the entire Los Padres National Forest which reaches into Santa Barbara County. That document is not specific to the Nacitone watersheds portion of the Los Padres National Forest, but includes general strategies that may yield opportunities for collaboration in the Nacitone. For example, a Conservation Strategy Emphasis for the next 3-5 years on page 112 of the September 2005 Plan includes the following under *Education/ Information/Interpretation:*

- Importance of riparian and aquatic species habitat
- Value of vegetation management
- Importance of keeping vehicles on roads
- Importance of keeping foot traffic on wilderness trails
- Species linkages and corridors and biological diversity
- Importance of reducing exposure of wildlife to lead poisoning

There is also a Draft Environmental Impact Statement (EIS) Revised Land Management Plan. These documents should be reviewed for goals, objectives, or guiding principles that may align with Nacitone Watersheds Management Plan goals and objectives.

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www.nacitonewater.org

Bureau of Reclamation
http://www.usbr.gov/main/about/
http://www.usbr.gov/mp/aboutus.html

California Department of Forestry and Fire Protection
http://www.fire.ca.gov/

California Department of Water Resources
http://www.water.ca.gov/

California Department of Water Resources Division of Safety of Dams
http://www.damsafety.water.ca.gov/

California Environmental Protection Agency
http://www.calepa.ca.gov/

CAL FIRE- County of San Luis Obispo
http://www.cdfslo.org/

Heritage Ranch Owner's Association
http://hroa.us/main.htm

Monterey County Water Resources Agency
http://www.mcwra.co.monterey.ca.us/

National Oceanic and Atmospheric Administration (NOAA) Restoration Center
http://www.nmfs.noaa.gov/habitat/restoration/

Oak Shores Community Association
http://oakshores.us/

Regional Water Quality Control Board (RWQCB)
http://www.swrcb.ca.gov/index.shtml

San Luis Obispo County Water Resources Advisory Committee
http://www.slocountywater.org/site/Water%20Resources/Advisory%20Committee/

San Luis Obispo County Public Works Department
http://www.slocounty.ca.gov/PW.htm

Nacimiento Water Project
http://www.slocounty.ca.gov/PW/NacWP.htm

Upper Salinas Las Tablas Resource Conservation District
http://www.us-ltrcd.org/long-range.html

United States Bureau of Land Management
http://www.blm.gov/wo/st/en/info/About_BLM.html

United States Fish and Wildlife Service
http://www.fws.gov/habitatconservation/wrda.htm

USFWS Partners Program
http://ecos.fws.gov/partners/viewContent.do?viewPage=home

Glossary

Alluvial - clay, silt, sand, gravel, or similar sediment material deposited by running water

Beneficial use – Historical, present, and potential uses of water in the Basin as defined by the RWQCB. The intent is to ensure the continuance of beneficial uses and establish compatible water quality standards as well as the level of treatment necessary to maintain the standards.

Confluence - the meeting place of two streams

Critical habitat – a specific area, identified by the NOAA Fisheries and/or USFWS, in which are found physical or biological features essential to the conservation of the species, and which may require special management considerations or protection. Multiple impacts are considered when designating critical habitat.

Electrofishing – a common fish population monitoring technique that uses electricity to stun fish before they are caught and counted. The survey determines abundance, density and species composition.

Epilimnion – the water layer overlying the thermocline of a lake

Evaporation – dissipation of water into vapor usually caused from heating by the sun groundwater basins

Habitat - the place or environment where a plant or animal naturally lives

Hydrophytic – a plant that grows in water or very moist ground; an aquatic plant

Hypoliminion – the water layer below the thermocline of a lake

Mean daily discharge – average stream flow per day

Mitigation – an action that results in a smaller impact or a compensates for an unavoidable impact

mg/L – milligrams per liter; a unit of measurement to express the concentration of a substance in a solution; same as "parts per million (ppm)" for aqueous solutions

Non-point source – pollution arising from many unidentifiable sources i.e. agriculture

Point source – pollution arising from a single identifiable source i.e. wastewater outfall

Redd – salmon nest

Riparian - area on the bank of a watercourse

Thermal refuge – stream area, usually a tributary or confluence, used by Steelhead for its cooler waters as refuge from warmer waters of the main channel.

Thermocline - the region in a thermally stratified body of water which separates warmer surface water from cold deep water and in which temperature decreases rapidly with depth

Turbidity – opaqueness/ clarity of water due to suspended sediment loads

Unincorporated – areas falling outside of city limits such as County lands and towns

Urban reserve lines – designated line beyond city limits where development will focus in the future

Watershed – the land area that contributes runoff to a particular water body

Wild and scenic - selected rivers that possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values that are preserved in free flowing condition with their immediate environments for the benefit and enjoyment of present and future

Abbreviations

BMP	Best Management Practice
BRAC	Base Realignment and Closure
CCAMP	Central Coast Ambient Monitoring Program
CCRWQCB	Central Coast Regional Water Quality Control Board
CEQA	California Environmental Quality Act
Cfs	cubic feet per second
CNDDB	California Natural Diversity Database
CSD	Community Service District
DO	Dissolved Oxygen
EIR	Environmental Impact Report
EPA - (US)	Environmental Protection Agency
FHL	Fort Hunter Liggett
GIS	Geographic Information Systems
INRMP	Integrated Natural Resources Management Plan
IRWMP	Integrated Regional Water Management Plan
IWMP	Integrated Watershed Management Plan
LID	Low Impact Development
LRMP	Land and Resource Management Plan
MCFCWCD	Monterey County Flood Control and Water Conservation District
MCWRA	Monterey County Water Resources Agency
MOU	Memorandum of Understanding
MSL	Mean Sea Level
MTBE	Methyl Tertiary-Butyl Ether
NEPA	National Environmental Protection Act
NGVD 29	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRWMAC	Nacimiento Regional Water Management Advisory Council
NWP	Nacimiento Water Project
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board (Central Coast Region)
SAM	Central Coast Water Quality Data Synthesis Assessment and Management Project
SH&G	Swanson Hydrology & Geomorphology (a private company)
SVWP	Salinas Valley Water Project
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
VOC	Volatile Organic Compounds
WRI	Watershed Resources Inventory

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Resources for Residents and Landowners

Water Quality

- Facts about Cyanobacteria & Cyanobacterial Harmful Algal Blooms

Center for Disease Control and Prevention
http://www.cdc.gov/hab/cyanobacteria/facts.htm

- Klau/ Buena Vista Mine Superfund Site

U.S. Environmental Protection Agency
http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/95831d90484434d7882574260072fadf/dcb0a4770abe6b618825746e0060ae01/$FILE/Klau6_08%2091kb.pdf
http://www.epa.gov/superfund/sites/npl/nar1732.htm

- Mercury Impacts/ Fish Advisories

http://www.dnr.state.wi.us/org/caer/cea/mercury/impact.htm
http://www.ehib.org/topics/BifoldForWeb.pdf
http://www.ehib.org/topic.jsp?topic_key=173

- Alternative Review Process

Upper Salinas Las Tablas Resource Conservation District
http://www.us-ltrcd.org/review.html

- Handbook of Agricultural Conservation Practices

Monterey Resource Conservation District
http://www.rcdmonterey.org/pdf/AgHandbook.pdf

- Cover Up Story: Erosion Control Handbook

Upper Salinas Las Tablas Resource Conservation District & SLO County
Copies available from:
US/ LT Resource Conservation District
(805) 434-0396 ext. 4

Water Projects

- Salinas Valley Water Project

http://www.mcwra.co.monterey.ca.us/welcome_svwp_n.htm

- Nacimiento Water Project

http://www.slocounty.ca.gov/PW/NacWP

Rangeland Management & Grazing

- California Rangeland Resolution

http://www.rangelandtrust.org/RangelandResolution6-24-08.pdf

- California Rangeland

UC Davis Extension
http://californiarangeland.ucdavis.edu/

- Grazing Handbook

Sotoyome Resource Conservation District
http://sotoyomercd.org/GrazingHandbook.pdf

- Riparian Area Management: Grazing Management for Riparian-Wetland Areas, TR 1737-14 1997

Bureau of Land Management and the Forest Service
Copies available from:
BLM, National Business Center, BC-650B
PO Box 25047
Denver, Colorado 80225-0047

- Management reduces E. coli in irrigated pasture runoff

Knox, Tate, Dahlgren and Atwill, 2007
http://calag.ucop.edu/0704OND/pdfs/IrrigationEcoli.pdf

- Significant Escherichia coli attenuation by vegetative buffers on annual grasslands

Tate, Atwill, Bartolome, Nader, 2006
http://jeq.scijournals.org/cgi/reprint/35/3/795

Fire

- Homeowner's Checklist: How to Make your Home Fire Safe

California Department of Forestry and Fire Protection
http://www.fire.ca.gov/communications/downloads/fact_sheets/Checklist.pdf

- Residential Burning

http://www.slocleanair.org/programs/residential.asp

Roads

- Low Maintenance Roads for Ranch, Fire and Utilities Access

Wildland Solutions
http://nohvcclibrary.forestry.uga.edu/SCANNED%20FILES/T-0028.pdf

Agricultural Water Quality

- Agriculture Management Series includes cover crops, access roads, filter buffer strips, self-monitoring of farm or ranch, rock energy dissipaters, and grassed waterways (GW 101 through 106-2006)

San Luis Obispo Farm Bureau, Natural Resource Conservation Service

Contact:
The San Luis Obispo Farm Bureau
651 Tank Farm Rd.
San Luis Obispo, CA 93401

Recreation

- ABC's of California Boating Law

CA Department of Boating and Waterways, 2007
http://www.dbw.ca.gov/Pubs/Abc/

Species and Habitat

- How to Grow California Oaks

McCreary, UC Cooperative Extension
http://danr.ucop.edu/ihrmp/oak04.htm

- Wildlife Among the Oaks

Johnson, Integrated Hardwood Range Management Program
http://danr.ucop.edu/ihrmp/allpubs.html

Waterway Management Plan

VOLUME I

San Luis Obispo Creek Watershed

City of San Luis Obispo
Department of Public Works
955 Morro Street
San Luis Obispo, California 93401

County of San Luis Obispo
Flood Control District - Zone 9
1050 Monterey Street, Room 207
San Luis Obispo, California 93408

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1. INTRODUCTION

1.1 Background

San Luis Obispo Creek (SLO Creek) and its tributaries have significant problems that involve recurrent damaging floods and bank instability. These problems require active channel management. Some reaches of the creeks have areas with desirable riparian habitat, but they occur in discontinuous or fragmented segments, with long segments of degraded habitat. These areas provide opportunities for stream habitat enhancement and riparian restoration. Needed management actions for the waterways include channel sediment removal, vegetation control, stream restoration and enhancement, repair of existing failing bank protection structures, and construction of new bank protection and flood control channel modifications.

These management actions can impact wetlands within the stream zone, as well as surface water. Approval or permitting from the U.S. Army Corps of Engineers (ACOE), Central Coast Regional Water Quality Control Board (Regional Board), and California Department of Fish and Game (CDFG), collectively Regulatory Agencies will be required. Since there are endangered species present within SLO waterways, including California red-legged frog and southern steelhead, consultation with the U.S. Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS) will also be crucial for any project involving disturbance, modification or management of creekside water resources.

The City of San Luis Obispo last prepared a comprehensive Flood Management Plan in 1977, in response to the disastrous floods of 1969 and 1973 (Nolte, 1977). The plan was ambitious in scope and costs, but had some serious environmental impacts associated with proposed channel widening. As a result, only portions of the plan were implemented (such as replacement of undersized and old bridges). Since preparation of the 1977 plan, the City has experienced damaging floods on several other occasions: especially in 1995.

The 1995 flood caused widespread damage throughout the SLO watershed, including out-of-bank flooding and extensive bank erosion. In response to the damage, the City requested permits from the ACOE and other regulatory agencies to repair damage at the worst public areas. The City also decided to take a new look at flooding problems and to develop a new plan that would address the frequency and magnitude of flooding, in an environmentally sensitive and cost effective manner.

In response to the City's request for a series of ACOE Nationwide Permits for wetlands fill to construct bank repair projects at ten locations, and with concerns regarding potential cumulative impacts on creek resources, the Regulatory Agencies collectively requested preparation of a comprehensive, watershed-based management plan for SLO Creek. This Waterway Management Plan (WMP) was prepared in response to that request and will form the basis for future project planning, decision making and permitting.

The overall Waterway Management Plan (WMP) program is contained in a three volume set of reports (Volumes I through III). The WMP is Volume I and contains inventory

information, a detailed hydrologic/hydraulic analysis of the watershed and its main tributaries, and an identification of the management problems and management needs of the waterways. Alternatives are reviewed for addressing flooding, bank instability, and habitat protection and enhancement, and a preferred project is presented.

Volume II presents a Stream Management and Maintenance Program (SMMP) for the waterways of the San Luis Obispo Creek Watershed. This document outlines the planning, design, and permitting approach the City and County will utilize for routine stream maintenance, such as vegetation management, bank repair, and sediment removal. Policies and Best Management Practices for these activities are also described. This document (Volume I) contains a brief summary of the SMMP document.

Volume III is a Drainage Design Manual (DDM), which contains revised policies for floodplain and stream corridor management and provides new design flows for stream channels within the City of San Luis Obispo. Procedures for hydrologic and hydraulic analysis, and guidelines and design criteria for the design of channel, storm drain systems, stormwater detention facilities, bank repair and stream restoration, and erosion control are presented in the DDM. Important policy revisions of the DDM are also summarized in this Volume (Waterway Management Plan).

Because of the large scope of the overall work program and the need to complete some management activities (principally bank stabilization) during the fall of 1998, prior to initiation of winter rains and high flows, the work program was divided into two phases, Phases I & II. Phase I was restricted in scope and geographic area, and addressed immediate management needs within a defined study area, generally the southern half of the City. Phase II would address overall stream corridor management throughout the SLO Creek watershed, including development of hydrologic and hydraulic models, flood management, sediment management and riparian restoration. In addition, Phase II would be based on comprehensive inventories and analysis, a Geographic Information System (GIS) to house the technical inventory and management data, and design criteria handbooks and maintenance manuals.

In April 1997, a Phase I report was prepared on behalf of the City and San Luis Obispo County Flood Control and Water Conservation District (Zone 9) that addressed problems of bank erosion at eight locations along several reaches of SLO Creek (Questa, 1997). These were areas damaged by the 1995 flooding, and most in need of management and bank repair. The Phase I report and the subsequent Design Concept Plan was submitted to the ACOE as part of the application for an Individual Section 404 Wetlands Fill Permit for these sites. The reports were also used as background information in submittals to the Regional Board for application for a Section 401 Water Quality Certification, Section 404 wetlands fill permit application and for the required CEQA/NEPA documentation. A separate Streambed Alteration Agreement was also obtained from the CDFG. Consultation and coordination with CDFG, USFWS and NMFS was required under Section 9 of the Endangered Species Act, because of the potential and likely presence of endangered species in the study area.

Following acceptance of the Phase I Report and the issuance of an Individual Permit by the ACOE and the CDFG, approximately 425 meters (1400 lineal feet) of bank repair (using

biotechnical methods) was completed in the late summer and fall of 1999. Mitigation included creek enhancement and restoration (mainly between Prado Road and Los Osos Valley Road) in addition to on-site planting with native plants at the bank repair sites. Zone 9 funded the bank repairs, with some funds also received from the Federal Emergency Management Agency (FEMA). The City also committed to preparation of this Phase II Waterway Management Plan (WMP).

1.2 Project Location

The project area covers the entire San Luis Obispo Creek watershed. San Luis Obispo Creek originates in the foothills of the Santa Lucia Range near Cuesta Grade, flowing approximately 29 km (18 miles) to its discharge to the Pacific Ocean at San Luis Bay, near the community of Avila Beach. The creek closely follows State Highway 101 along most of its route. The SLO Creek watershed is centrally located in San Luis Obispo County between the Santa Lucia Mountains and coastal hills of central California (**Figure 1-1**). The City of San Luis Obispo covers an area of approximately 9.5 square miles near the center of the watershed, with the remaining watershed area (approximately 217 km^2 or 84 $mi^{2)}$ in County jurisdiction. The WMP focuses on the main stem of San Luis Obispo Creek but also incorporates the following major tributaries to San Luis Obispo Creek:

- East Fork of San Luis Obispo Creek
- Prefumo Creek
- Froom Creek
- Stenner Creek
- Brizziolari Creek (tributary to Stenner Creek)
- See Canyon Creek
- Old Garden Creek (tributary to Stenner Creek)
- Davenport Creek

1.3 Purpose and Objectives of the Waterway Management Plan

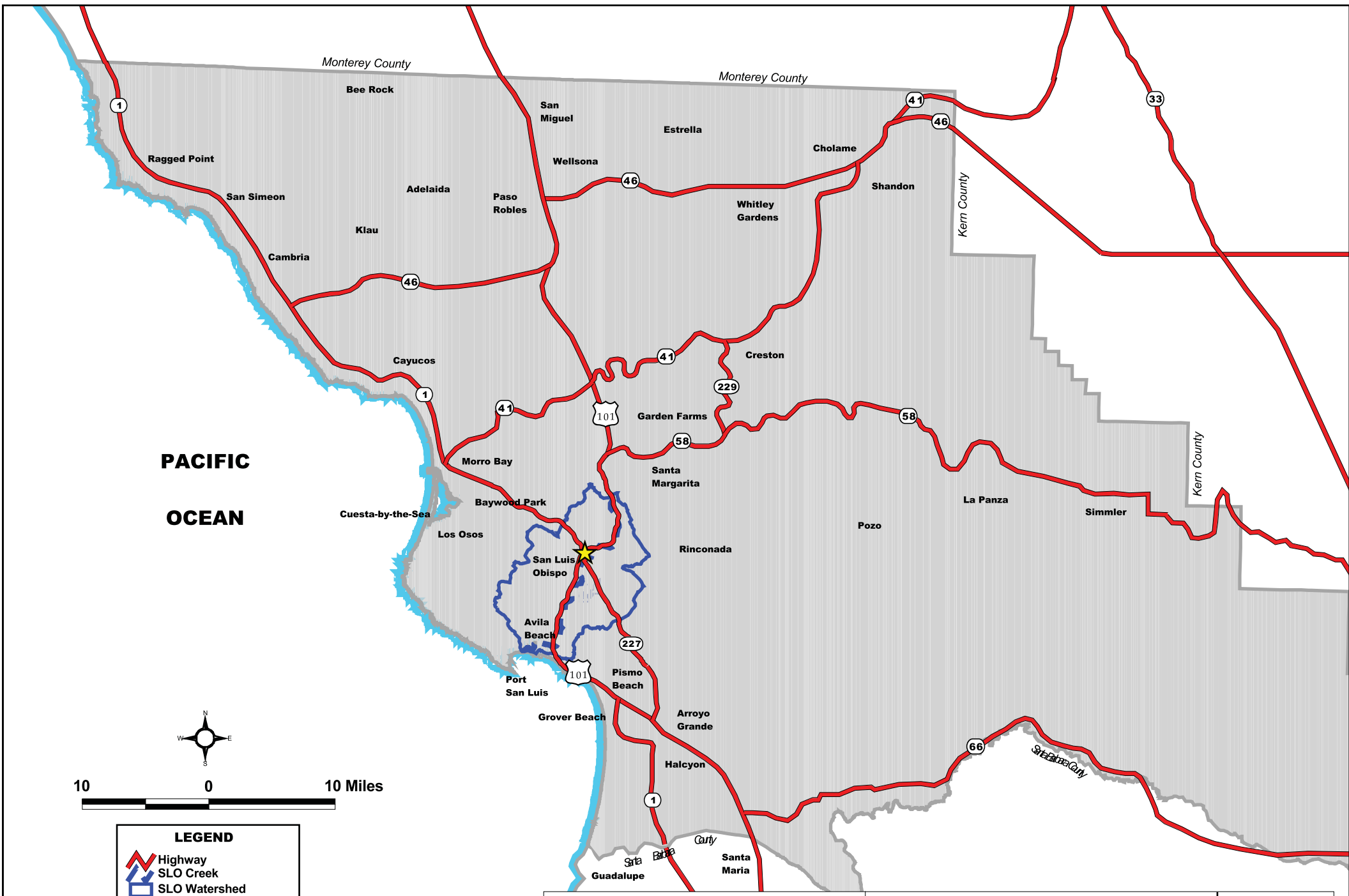
The purpose and objectives of the WMP, as developed by the Zone 9 Advisory Committee in consultation with the Regulatory Agencies are as follows:

Purpose

Develop an approach and schematic plans to address flooding, erosion, water quality, and ecological issues in the SLO Creek Watershed that can be implemented with approvals from various regulatory agencies.

Objectives

1. Identify and prioritize the amount and extent of flooding, erosion, water quality, and ecological issues in the SLO Watershed.


Monterey County
Monterey County
Kern County
Kern County
Santa Barbara County
Bee Rock
San Miguel
Estrella
Cholame
Ragged Point
Wellsona
Shandon
San Simeon
Adelaida
Paso Robles
Whitley Gardens
Klau
Cambria
Cayucos
Creston
Garden Farms
PACIFIC
OCEAN
Morro Bay
Santa Margarita
Baywood Park
La Panza
Simmler
Cuesta-by-the-Sea
Pozo
Los Osos
Rinconada
San Luis Obispo
Avila Beach
Port San Luis
Pismo Beach
Grover Beach
Arroyo Grande
Halcyon
Santa Maria
Guadalupe
1
33
41
46
58
66
101
227
229
N
W
E
S
10
0
10 Miles
LEGEND
Highway
SLO Creek
SLO Watershed
SLO County
city of san luis obispo
PUBLIC WORKS DEPARTMENT
COUNTY OF SAN LUIS OBISPO
Watershed Location Map
SLO Creek Phase II
Waterway Management Program
QUESTA ENGINEERING CORPORATION
Figure
WMP 1-1

2. Identify and develop programs to address flooding, erosion, water quality, and ecological issues in the SLO Watershed.

3. Develop guidelines for design of future development or reconstructed developments in the SLO Watershed.

4. Develop a programmatic environmental and permitting review process for implementation of Objectives 2 and 3, as applicable.

5. Develop an Implementation Program.

1.4 Planning Process, Information Sources and Study Team

The Phase II planning process was initiated by the Zone 9 Advisory Committee and the City and County in January 2000. The approximately two and one half year planning process has involved the participation of City and County Engineering and Planning staff, landowners, regulatory agencies, and the general public, culminating in the development of this WMP and related documents. An informal Technical Advisory Committee (TAC) composed of representatives from the City, County, select resources and regulatory agencies, and other interested individuals and groups provided guidance in screening, selection and development of alternative waterway management approaches. Many members of the TAC also sit on the Zone 9 Advisory Committee (SLO Creek watershed). The study team presented information and alternatives at the monthly Zone 9 Advisory Committee meetings, which were open to the public.

Tasks included completion of detailed resource inventories, hydrologic and hydraulic modeling and analysis, problem identification, development and screening of alternatives to address the identified problems, and selecting a short list of alternatives for further environmental review and public hearings.

Advisory Committee members represented various interest groups, including City, County, Caltrans, Cal Poly, the Avila Beach area, and the agricultural community. In addition to guiding the scope of work and providing input and comments on each step of the process, the Advisory Committee members also insured that the developing plan was compatible with their interest groups' opinion and needs. For instance, a key issue of concern to the Avila Valley area is to make sure that any flood management projects proposed in the City of San Luis Obispo do not make flooding problems worse in their areas. A key concern of the agricultural community is to make sure that any new stream corridor and floodplain management regulations do not create new regulatory or permit procedures for routine agricultural practices, and that the Waterway Management Plan does not supersede the Goals, Policies, and Programs of the Agricultural and Open-Space elements of the San Luis Obispo County General Plan.

Members of the Zone 9 Advisory Committee and agency representatives include:

Agency	**Member**	**Alternate**
City of SLO-City Council	Jan Marx	Christine Mulholland
City of SLO-Staff	Jay Walter	Matt Horn
City of SLO-Public at-large	John French	*vacant*
Agricultural Liaison Advisory Board	David Pereira	Hunter Francis
Avila Valley Advisory Council	Carol Kiessig	*vacant*
Cal Poly State University	Brent Hallock	Brian Dietterick
Caltrans	Lance Gorman	*vacant*
Public at-large	Steve Gregory	Wayne Peterson

Questa Engineering Corporation of Point Richmond, California, provided technical engineering support. Morro Group, Inc., provided support for biology and the enhancement element recommendation. Marcelo Espiritu and Dale Norrington working under the supervision of Rollin Strohman, Ph.D., from the California Polytechnic State University at San Luis Obispo (CalPoly) assisted in the stream geomorphic field inventory, GIS development, and project web site development. Project documents can be found at www.slocity.org/natural resources/relatedlinks.asp or the CalPoly website.

A number of prior watershed, stream surveys and flood control studies were used in preparing this report, in addition to the field work and hydrologic and hydraulic analysis completed as part of the Phase II investigations. Previous investigations that were consulted included:

- *Floodplain Information San Luis Obispo Creek and Tributaries Vicinity of San Luis Obispo, San Luis Obispo County, California*, Nov. 1974 (Report prepared by U.S. Army, L.A. District. Provides information on flood history, flood damages, and extent of floodplain, but not a Flood Control Plan)

- *Flood Control and Drainage Master Plan for the San Luis Obispo Creek Watershed*, Aug. 1977 (First comprehensive Flood Control Plan for the City, prepared by George S. Nolte & Associates)

- *Flood Insurance Study, City of San Luis Obispo*, 1978 (Provides information on flooding and floodplains based on 1977 Nolte hydrologic and hydraulic analysis, issued by FEMA)

- *Flood Insurance Rate Maps for the City of San Luis Obispo*, 1981 (Floodplain Maps prepared by FEMA and used by the City for Floodplain Regulation)

- *San Luis Obispo Creek Restoration Plan*, 1988 (First watershed restoration plan for SLO Creek, prepared by Land Conservancy of San Luis Obispo County)

- *Nutrient Objectives and Best Management Practices for San Luis Obispo Creek*, May 1994. (A report focused on prepared for the Central Coast Regional Water Quality Control Board by the Coastal resources Institute of California Polytechnic Institute, SLO)

- *Final Plan for Restoration Actions within the San Luis Obispo Creek Watershed -Unocal Oil Spill, Avila Beach, CA 1992* (A report that summarizes and prioritizes restoration opportunities in the SLO Watershed, prepared for the Avila Beach Trustee Council by the Land Conservancy of San Luis Obispo County)

- *Biological Resource Assessment and Impact Analysis for the SLO Creek Water Reuse Project*, 1995 (Consultants report and EIR prepared for City of SLO by Fugro West, Inc.)

- *San Luis Obispo Creek Watershed Hydrologic Survey*, 1996 (Report prepared by the Land Conservancy of San Luis Obispo County for the Central Coast Regional Water Quality Control Board. Primarily addresses runoff hydrology and creek conditions, with focus on creek restoration and bank stabilization, not flood management)

- *San Luis Obispo Creek Trout Habitat Inventory & Investigation, 1995* (Report prepared for the Land Conservancy of San Luis Obispo County by P. Cleveland, fisheries biologist)

- *Phase I – San Luis Obispo Creek, 1997,* (Report prepared for the City and San Luis Obispo County Flood Control and Water Conservation District (Zone 9))

- *Storm Drain Master Plan for the Airport Area Specific Plan*, Jan. 1999 (Prepared for the City of SLO by Boyle Engineering Corporation)

- *San Luis Obispo Creek Watershed Enhancement Plan*, March 2002 (Report prepared by The Land Conservancy of San Luis Obispo County is an update of the 1988 report, further identifying problems and prioritized opportunities for restoration)

Other references used in preparation of this Plan are in **Section 9**.

1.5 WMP Components

There are five principal components of this Waterway Management Plan:

- A Stream Maintenance and Management Program (SMMP) covering routine stream maintenance practices and procedures and presenting proposed Best Management Practices as Volume II

- A new Drainage Design Manual (DDM) for storm water, flood control, and bank repair design as Volume III

- A Flood Management Plan that outlines the conceptual flood control alternatives that are proposed as the Preferred Project (Volume I)

- A Bank Stabilization Program that provides a management framework and conceptual plans for addressing current and future bank instability problem areas (Volume I), and

- A Habitat Enhancement and Restoration Program that provides a conceptual plan and framework for stream resource enhancement, restoration, and protection (Volume I).

1.6 Waterway Management Plan Organization

Volume I of the three-volume report is designed to be a "Concept Plan" for Waterway Management and a reference document for use in subsequent, detailed project planning, permitting, and CEQA/NEPA review. As such it will guide the development of future projects to construct flood management channels and storm drains, repair eroding banks, and manage the vegetation and other resources along the creeks of the watershed, and guide restoration and enhancement. The permit application and environmental documents will incorporate by reference sections of this WMP, DDM, and SMMP. The WMP includes supporting information contained in the appendices:

Section 1 describes the background and organization of the WMP, including project objectives and a summary of planning procedures.

Section 2 provides an overview of the resource inventory, including geomorphic and hydrologic conditions of the creek, existing hydraulic structures, erosion problem areas, and bank stabilization needs, as well as, existing biological conditions of the creek, including information on the plant communities, wildlife and fisheries, and rare and endangered species.

Section 3 describes the planning constraints, management needs, environmental sensitivities, and the opportunities for habitat restoration and enhancement.

Section 4 provides a watershed wide perspective to recognize and address the resource management problems of the watershed in an integrated and comprehensive fashion with eight goals and action items.

Section 5 presents four principal components of the Preferred Project. The preferred project for environmental review purposes was developed by the Zone 9 Advisory Committee and confirmed with some modifications by the San Luis Obispo City Council: Preferred project components include:

- A summary of Stream Maintenance and Management Procedures
- Design guidelines and requirements for storm drain facilities system design and channel modification projects

- A Bank Stabilization and Repair program
- A Habitat Enhancement and Protection Program

Section 6 contains an outline of the main components of the preferred project for flood management actions, including structural channel modifications and non-structural elements such as revised floodplain management regulations, possible purchases of flood-prone properties and flood proofing.

Section 7 evaluates project costs and expected project benefits.

Section 8 describes the Implementation and Financing Plan, including a discussion of the recommended prioritization of identified projects, implementation schedule, and funding sources.

Section 9 lists the references and literature cited.

Section 10 is a glossary of technical terms for use by the reader.

Appendix A of Volume I contains the creek geomorphic GIS Inventory data; **Appendix B** is the Biological Resources Inventory, **Appendix C** contains the Hydraulic and Hydrologic Report, and **Appendix D** discusses Project Alternatives.

2. RESOURCE INVENTORY

2.1 Introduction

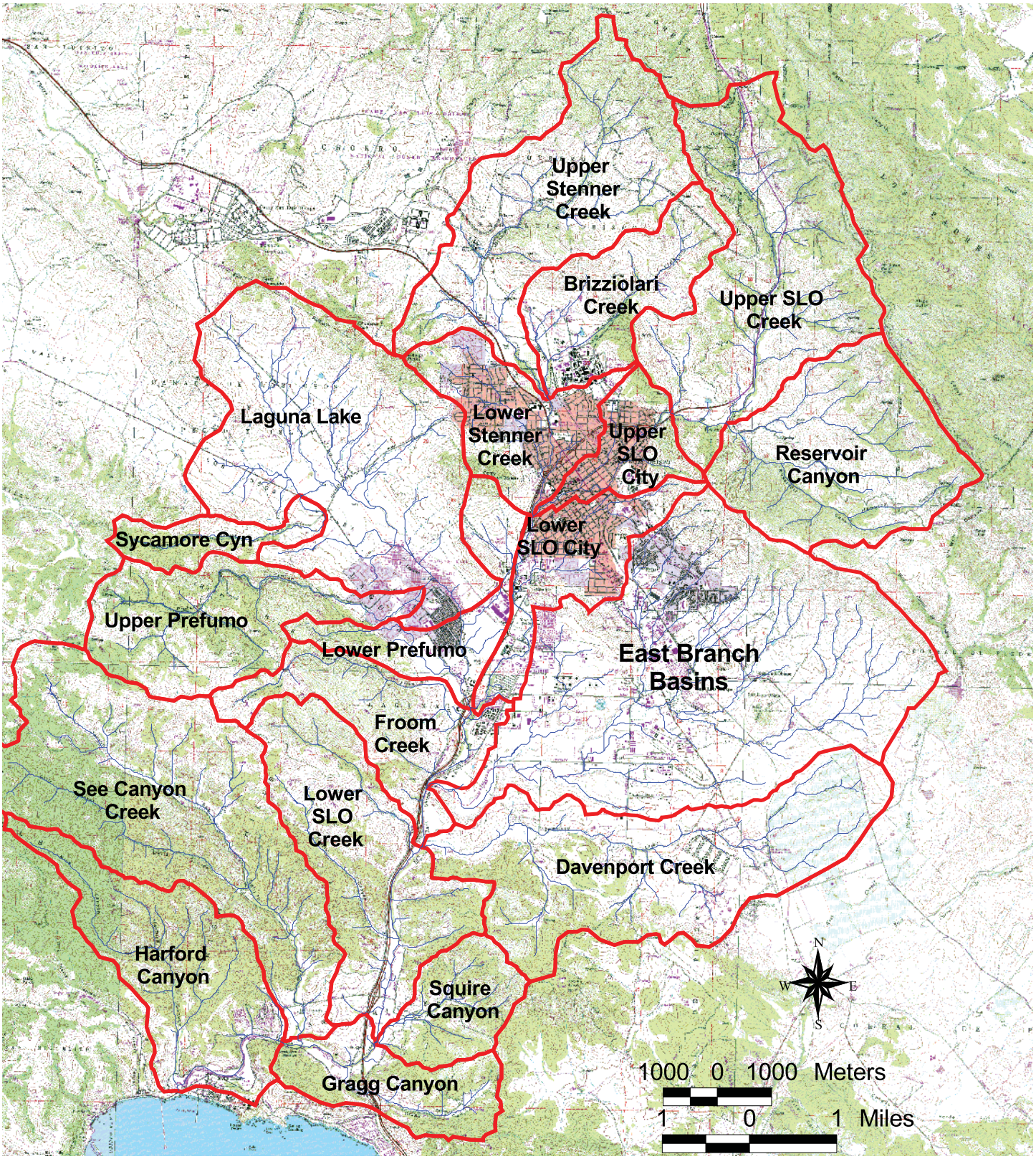
Management of a stream corridor requires an understanding and analysis of its watershed, including general watershed physical and biological characteristics, as well as the characteristics of the system of streams that drain it. The analysis and evaluation of watershed and waterway management problems and management needs requires the integration of basic information on the geology, geomorphology, hydrology and hydraulics, and biology of the system. Since a watershed and its streams respond to both natural and human influences, and the response manifests itself over long periods, the analysis should also include a review of the historical context of the changes that have occurred within the watershed and to its streams.

This section of the Waterway Management Plan describes the general geologic, hydrologic, and biologic characteristics of the SLO watershed, and summarizes the detailed resource inventory information that was collected as part of WMP preparation. It includes a description of the watershed, an overview of current and historical land uses and a generalized description of the existing geomorphic and bank and bed conditions of each reach.

Detailed inventory information of the creek channel geomorphic or stream physical conditions is presented in **Appendix A**, while **Appendix B** presents information on the biological resources that were inventoried. The inventory includes maps and data base information prepared in a GIS that is available on the City of San Luis Obispo's server (www.slocity.org/natural resources/relatedlinks.asp). **Appendix C** summarizes the results of the hydrologic and hydraulic analysis completed for the WMP.

2.2 Watershed Characteristics

SLO Creek is the major waterway that runs through the City of San Luis Obispo. The main stem of SLO Creek flows predominantly southwest, approximately 29 kilometers from its headwaters in the Santa Lucia Range to the Pacific Ocean at Avila Beach. The SLO Creek watershed extends from a high elevation of 750 meters above sea level near Cuesta Grade to sea level at Avila Beach. The City of San Luis Obispo is at an elevation of about 70 meters (downtown). The drainage area of the SLO Creek watershed at its mouth is approximately 218 km^2. The basin is a slightly elongated area about 21 km long and between 10 and 16 km wide, with a dendritic drainage pattern (**Figure 2-1**).



city of san luis obispo

PUBLIC WORKS DEPARTMENT

Watershed and Major Sub-Basins

SLO Creek Phase II
Waterway Management Plan

QUESTA ENGINEERING CORPORATION

Figure

WMP 2-1

FILE REFERENCE: c:\arcview projects\98202 slo phase ii\98202hydrology.apr
LAYOUT: Figure 1 - Base Map B
DATE: Feb 4, 2002

The upper watershed is steep, and SLO Creek and its tributaries flow through narrow canyons with steep stream gradients in their headwaters areas. From its headwaters SLO Creek spills onto a small sparsely developed grassy plateau-like area below Cuesta Grade at Reservoir Canyon, before descending onto the gently to moderately sloping alluvial plain occupied by the City of San Luis Obispo. Within the City limits, the main stem joins Stenner Creek, which drains primarily agricultural and range land in the Santa Lucia Range, and at the lower end of the City by Prefumo Creek, which drains the Laguna Lake and above that, the steep chaparral and oak wooded lands of Prefumo Canyon. CalPoly is located at the northern end of the City, generally between Brizziolari and Stenner Creeks. Other major tributaries include:

- Brizziolari and Old Garden Creeks, both tributaries to Stenner Creek, within the northern part of the City
- East Fork (which drains an area of generally flat to rolling relief on the east side about 2 km below the confluence of Prefumo Creek and the City limits),
- Davenport Creek, (which drains a more rugged canyon area on the east side below East Fork), and
- See Canyon, a wooded canyon on the lower west side, above Avila Beach.

While SLO Creek is incised into an alluvial plain within the downtown and upper residential area of City of SLO, it crosses the broader upper Los Osos Valley and the lower Laguna Lake area before changing its character below Froom Creek and Los Osos Valley Road. The creek descends through a narrow alluvial valley bounded by the steep Irish Hills in this area. The narrowest part of this segment (only about 1 25 meters wide) begins near the confluence of Davenport Creek with SLO Creek, and is aptly called “The Narrows” by local residents. The SLO Valley downstream of the Narrows ranges from about 300 meters to 600 meters wide.

San Luis Obispo Creek turns abruptly westward from its southerly ascent through the City and lower valley area to enter a more narrow and steep-sided canyon before discharging into an estuary area at Avila Beach below the See Canyon confluence.

Only about 11% of the watershed is urbanized; principally the town of San Luis Obispo and the surrounding unincorporated area, and the small community of Avila Beach. However, the ubranzied area upstream of the lower urban reserve limits of the City (near Los Osos Valley Road) is about 15% of the watershed above this point. The urbanized area is predominantly suburban, with the exception of the central downtown area where building densities are higher with a larger percentage of impervious surfaces. Many watershed researchers believe streams begin to experience significant problems, including channel bed and bank erosion, when dense urbanization (or effective impermeable surface area) exceeds 10 -15% of the watershed (Booth and Reinelt, 1993, Schueler, 1994). Much of the upper and lower watershed is in open space, used as grazing land or range.

Upper watershed areas are not heavily wooded; oak forests occur predominantly only on north facing canyon slopes and canyon bottoms, with chaparral vegetation generally on steep south facing slopes and areas with shallow, rocky soils.

SLO Creek itself has a nearly continuous riparian corridor from its headwaters at Cuesta Grade to Avila Beach. However in many areas the corridor is narrow, has a sparse canopy cover, or is degraded with a significant mixture of non-native trees and shrubs. Although sheep and cattle grazing of hillside grassland areas may have been intensive in the historic past, that is not the case today. Cultivated agriculture is not extensive, mainly concentrated along the valley lands adjacent to SLO Creek between Los Osos Valley Road (LOVR) and San Luis Bay Drive.

2.3 Climate

The climate of the SLO Creek watershed varies significantly from the coast to the areas of the foothills and mountains of the Santa Lucia Range. Precipitation, in the form of rain, occurs primarily between November and March. It is least along the coast (averaging about 40 cm) but increases as the clouds move inland and rise over the mountains. The highest rainfall (averaging 76 cm) is normally recorded along the ridge tops northeast and southwest of the City of San Luis Obispo. Rainfall in the City averages approximately 54 cm. However, as a coastal watershed, it is subject to wide ranges in precipitation, from periods of drought, to unusually wet winters, and occasional short duration very high intensity storms, such as occurred in January and March 1995.

2.4 Biological Resources

Riparian vegetation is crucial to the maintenance and health of overall habitat quality. Well-developed, relatively undisturbed native riparian vegetation provides shelter and forage for a wide variety and abundance of wildlife. Riparian vegetation also provides stability for stream banks by reducing bank erosion, raindrop impact and erosion associated with overland flow. Additionally, riparian vegetation high in percent cover provides stream shading which, in turn effects water temperature, water quality and fisheries resources. The inverse is true for areas low in overall cover and diversity. These areas typically lack suitable habitat for native wildlife and fish, have increased erosion rate and bank failure and are lower in water quality. **Appendix B** contains a detailed *Biological Resources Inventory.*

Vegetation. Riparian plant community structure and composition vary according to environmental factors such as water regime, climate, disturbance frequency, substrate material, root-zone aeration, depth to ground water, width and depth of flood plain, aspect, slope, the presence and extent of exotic species, land use and water quality. A cross section of a typical stream corridor would reveal the extreme gradation that occurs in vegetative composition from hydric, aquatic bed and freshwater marsh to mesic, riparian forest and scrub, edaphic (conditions determined by soil characteristics). Coastal scrub and grasslands conditions persist where bedrock outcrops and shallow soils, or other soil conditions present limiting factors for plant growth. The structure of the riparian community occurring within

the planning area consists of a mixture of native and exotic species, with few areas of undisturbed mature dense riparian canopy.

Wildlife. Riparian habitats provide significant features required by a wide range of wildlife. The variety of plant communities and species, cover values, and the presence of water create conditions which provide food, water, migration and dispersal corridors, and escape, nesting and thermal cover for a rich assemblage of species. Riparian habitat provides year round and seasonal habitat, migratory stopovers and breeding areas for mammals, amphibians, reptiles, birds, fish and invertebrates.

Birds. SLO Creek supports a tremendous variety of resident and migratory bird species. Within the riparian corridor are a multistoried canopy and a mosaic of vegetative communities that support a wide range of habitat requirements. Birds commonly found within the riparian corridor include; great blue heron (*Ardea herdonias*), belted kingfisher (*Ceryle alcyon*), mallard (*Anas platyrhynchos*), black phoebe (*Sayornis nigricans*), common bushtit (*Psaltriparus minmus*) and red-winged blackbird (*Agelaius phoeniceus*) (Fugro, 1995).

Fisheries. In general, pool habitat is the areas of calm water typically located along the margin of streams, which provide calm, cool surroundings for large and small fish. Riffle habitat is swiftly flowing stretches with exposed rocks that provide a niche for small fish, mix oxygen with water and produce an important food source of insects. Flatwater habitat is moderately flowing stretches with little or no flow obstructions that, if deep and swiftly flowing, can provide habitat to larger fish. A stream in good condition ideally has a mixture of pool, riffle, and flatwater habitat. Excesive erosion in a watershed can fill in pools and clog gravels in riffles with sediment.

Many of the persistent polls, which contain water year-round, are found in the middle and upper reaches of San Luis Obispo Creek and its major tributaries. The lower planning area reaches are dominated by flatwater habitat. The predominance of flatwater results in a shortage of riffle and pool habitat. The geomorphic processes, which create pools and riffles, are dependent upon one and other. That is, without pools, riffles will not form and without riffles, pools will not form. The lack of pool habitat and riffle habitat should recognize these constraints and should be aimed at achieving optimal habitat enhancement for endemic riparian vegetation, anadromous fish, amphibians and small mammals. Enhancement efforts include: (a) increase in the overall diversity, extent and continuity of riparian vegetation; (b) the control and/or removal of invasive exotic vegetation; and, (c) improvements to aquatic habitat by creating additional pool-riffle sequences and instream cover. Enhancement objectives such as these would result in an increase in overall ecological integrity in addition to improved aesthetic and recreational values.

2.5 Geology

The San Luis Obispo Creek watershed is located in a geologically complex area within the Coast Range geomorphic province of California. This area is characterized by the widespread occurrence of deformed and partially metamorphosed marine rocks of the

Franciscan Complex (Jurassic to Cretaceous age). The rocks are pervasively faulted and fractured, increasing their instability on steep mountain slopes. In places they are intruded by generally large serpentine rock masses that create unusual erosion and stability problems. The Franciscan Assemblage, a melange or mixture of various rock types, forms the foundation underlying the City of San Luis Obispo, the bulk of the Santa Lucia Hills, and the eastern flanks of the Edna Valley. (Hall, 1977, 1979, Chipping, 1987).

A blanket of Cenozoic marine and non-marine sedimentary rocks, including the Monterey and Pismo Formations, overlie the Franciscan rocks over large parts of the watershed, particularly in the central and southern parts, including the Irish Hills. These rocks can be more resistant to erosion than the fractured Franciscan rocks.

Several faults, including the active Los Osos fault along the northern flank of the Irish Hills and the Edna Fault Zone further south in the Edna Valley area, cross the watershed. These and other faults in this area run in a general northwest-southeast direction, roughly transverse to the general southwest flow of SLO Creek. These faults control the local geology and because of both geologic uplift and differential erosion of rocks of varying hardness, form several prominent ridge systems in the City, and the outline of the drainage sub-basins. Cerro San Luis Obispo (one of a series of ancient volcanic plugs beginning at Morro Rock in Morro Bay and extending just east of SLO) forms a broken ridgeline to the west with Terrace Hill to the east, near the center of town. Another fault occurs on an east-west trending ridge (Water Tank Hill) cut through by SLO Creek on the south side, near the Madonna Road off ramp of Highway 101. This ridge consists of predominantly serpentine rock.

Typically, Franciscan and related rocks yield shallow to moderately deep stony/clayey erosive soils, which occur on steep landscapes. Areas of serpentine rocks generally support a less dense grass and brush cover, because of their inherent infertility. Their consequent slow recovery upon disturbance makes them highly susceptible to erosion. Because of the steepness of the Franciscan landscape and the shallow stony soils, rainfall runoff rates are typically very high.

Franciscan rocks are exposed in the creek bed and creek bank throughout many parts of the upper watershed, including the northern third of the City of SLO. These often occur as bedrock exposures in the creek channel bed where the creek has cut down through the rocks and across the structural grain of the Franciscan terrain

Rainfall infiltrates and flows slowly through the Franciscan formation and travels along its many fractures. It is a good source of early summer base flow in the upper reaches, as well as several perennial springs in the upper tributaries. Groundwater discharge can occur when stream channels cut across these fractures.

Several large or massive landslides are slowly impinging on SLO Creek within the upper watershed area. Large landslide masses are also characteristic of the steep terrain underlain by Franciscan rocks. These areas can be prone to mud slides and debris flows in small colluvial-filled secondary drainages on steep slopes in the upper watershed, particularly following fire or disturbance.

As SLO Creek enters the northern limits of the City, it begins a descent through moderately sloping alluvial fans and then the alluvial valley fill sediments of SLO valley. The valleys through which SLO Creek and its tributaries flow are underlain by both younger and older alluvial deposits (Hall, 1977). Several older alluvial deposits and stream terraces occur well above the modern floodplain in the watershed, attesting to the various episodes of sea level rise and fall, uplift and consequent stream erosion as the creeks have adjusted to the changing base levels.

As viewed in stream cuts, the alluvial fan deposits forming the plain that underlies the City are generally only about three to five meters thick. Based on the degree of soil profile development reported in the *Soil Survey of the San Luis Obispo County, Coastal Part* (United States Department of Agriculture (USDA), 1984), and the fact that most of the plain is well above even the FEMA 500-year flood, these fan deposits should be considered older alluvium, but stratigraphically younger than the older alluvium and stream terraces of Hall (1977).

SLO Creek and its tributaries have incised into this older surface, however they have backfilled a narrow stream zone along the major creeks with younger alluvium, the boundaries of which are approximated by the 500-year FEMA flood limits.

The alluvial deposits are underlain by hard Franciscan rocks, which are exposed in the lower creek banks and creek bed in the northern part of the City, and by reddish brown siltstones, claystones, and conglomerate of the Paso Robes Formation (older Pleistocene) throughout much of the central and southern part of the City. This weakly to moderately consolidated rock is also exposed in the channel bottom and lower bank slopes along much of the middle reaches of SLO Creek, and along the southern side of Los Osos Valley. Locally it may form a subsurface barrier or retardance layer to water infiltration and groundwater recharge. In many areas, infiltrating water apparently moves along the contact between the Holocene sediments and the claystone, where it is intercepted in the creek channel. The claystone may also form a limit to stream downcutting in some sections, favoring or forcing lateral migration of creek channels.

The red-brown unit of the Paso Robles Formation is apparently replaced by a dark brown consolidated clay bed (older alluvium) beginning below Los Osos Valley Road. This unit is also more resistant to stream erosion than the modern stream alluvium that overlies it.

East Fork flows roughly westward, at the base of the serpentine ridge, following the general east-west trend set by the Edna Fault zone, located just to the south and within the lower Edna Valley. From the widespread distribution of the Pleistocene Paso Robles formation, a major drainage must have once occupied the ancient Edna Valley and surrounding area, flowing westward. The deposits have now been uplifted and tilted westward, and a series of consequent streams have cut through the structural and topographic grain of the east-west trending Edna Valley, flowing generally southward to the ocean at Pismo Beach. These include Corral Hollow and Arroyo Grande Creeks. San Luis Obispo Creek, on the other hand, turns abruptly westward from its predominantly southern alignment about 0.5

kilometers from the coast, where it has cut a winding valley through steep hills underlain by various Tertiary sedimentary formations, to emerge at the coast at Avila Beach.

The alluvial floodplain deposits in the lower SLO Creek area, below LOVR and in the Laguna Lake area show little or no indication of horizonation or soil profile development. They should be considered recent alluvium. The Soil Survey indicates that these soils have a gleyed horizon located at a depth of about three or four feet. The blue-gray or grayed color is indicative of poorly drained or anoxic conditions created by a permanent high ground water table during the period these soils developed. This apparently is a relict feature, as the high groundwater table is now only a seasonal occurrence, with the water table likely lowered several meters (three to four) by the historic incision of San Luis Obispo Creek in this area. This incision or downcutting of the channel bed has caused significant secondary channel degradation or stream headcutting of East Fork and Davenport Creek. The dark colors of the surface soils indicate high organic matter accumulation, such as occurs in a swampy flood plain or backwater environment of lower velocity flows, consistent with the flatter stream gradients in this and the Laguna Lake areas.

2.6 Streamflow

The steepness of the upper watershed, its shallow soils, chaparral vegetation and the typically short-duration, intense rainfall pattern result in stream hydrographs that is very flashy. This means that the flow of water moves quickly through the system yielding high peak flows that drop quickly back to winter base flow levels once intense rainfall ceases.

Many of the tributary streams in the watershed are predominantly seasonal, with significant flows occurring only during the winter and spring months. It is also common for some streams or portions of streams to not flow at all in drought years, and to maintain near perennial flow, especially in their lower reaches, during wet years. However, flow in the main stem of SLO creek can be complex, with areas of deep sands and gravels in the creek channel, where summer flow is lost, interrupted by creek bed exposures of hard rock, where creek flow can be forced back to the surface. In general, flow in San Luis Obispo Creek becomes consistently perennial below Prefumo Creek, due both to the interception of groundwater by the increasingly incised channel, and by the introduction of highly treated wastewater from the City's treatment plant discharge above this location. Some flow is maintained in pools in many upper creek tributary areas, fed by shallow surface flow and inter-gravel flow. These pools are critically important to fish, aquatic organisms, and wildlife.

The native fish and aquatic organisms of the SLO Creek watershed have adapted their life histories to meet the environmental challenges of dry summers and periodic draughts. Significant disturbances to the physical conditions and habitat can have profound adverse impacts on them. Because most of the streams in coastal California are impacted by urban uses, many of the native fish and aquatic organisms are considered sensitive, threatened, or endangered species by state and federal resource agencies.

Significant variations in rainfall can cause natural streams and disturbed watercourses to experience extensive, widespread channel erosion and sedimentation in wet years, recovering during dry years. Bank erosion at channel bends can migrate downstream over a period of years, with the gradual recovery of eroded upstream bends. Many of the most significant bank erosion problems occur at channel bends, or in areas of a former meander pattern that has been straightened. In addition to degrading aquatic habitat, erosion and sedimentation can reduce the flow capacity of creeks. Vegetative growth in the channel (from a channel conveyance perspective) occurs in moderate or drought years due to the lack of flushing flows. With the moderate climate of SLO County, vegetation can flourish throughout the year. In many cases the obstructive vegetation includes young shrubby willows, introduced exotic woody plants and ground cover.

The natural stream courses and adjusted floodplain in many areas originally had a higher conveyance capacity in their upper bank and over bank areas, because the natural climax vegetation along the stream corridors consisted of mature sycamores, cottonwoods and tree willows. These tall single-trunk species have lower flow retardance (Manning's N value) than the shrubby willows and exotics. Currently, nearly all of the streams in the watershed have significant conveyance limitations. Channel conveyance is commonly equivalent to less than 25-year flood flow capacity with several reaches in the 10- to15-year flow capacity range.

Fire in the watershed, such as the Highway 41 area in 1994, can also have a significant effect on erosion and sedimentation. The sediment load detracts from channel capacity and alters fluid dynamics. The effect can persist over many years as the sediment bed load slowly works its way through the fluvial system. Increased flood risks result from sedimentation and dense channel growth. With limited channel capacities, management of shrubby lower bank vegetation and sediment management are critical.

Some small headwater tributaries originate on upper alluvial fans, at the front of the foothills and mountain slopes that ring San Luis Obispo valley. These fans have formed though debris and massive sediment flow events, and their natural stream courses may not be stable. There are significant maintenance challenges where urban development has occurred on these upper fans. Without maintenance, (culvert and storm drain clearing before and during major storm events), these channels may clog and migrate from their present form and location. Fortunately, biological values tend to be low at these sites.

2.7 Historical Context Channel Changes

A summary of the more significant historical changes to the watershed and its creeks was prepared, based on a review and comparison of current and historic U.S. Geological Survey topographic maps and aerial photography on file at the University of California, Berkeley Map Library, and the Menlo Park Library of the U.S. Geological Survey. Among the historic USGS topographic maps reviewed were:

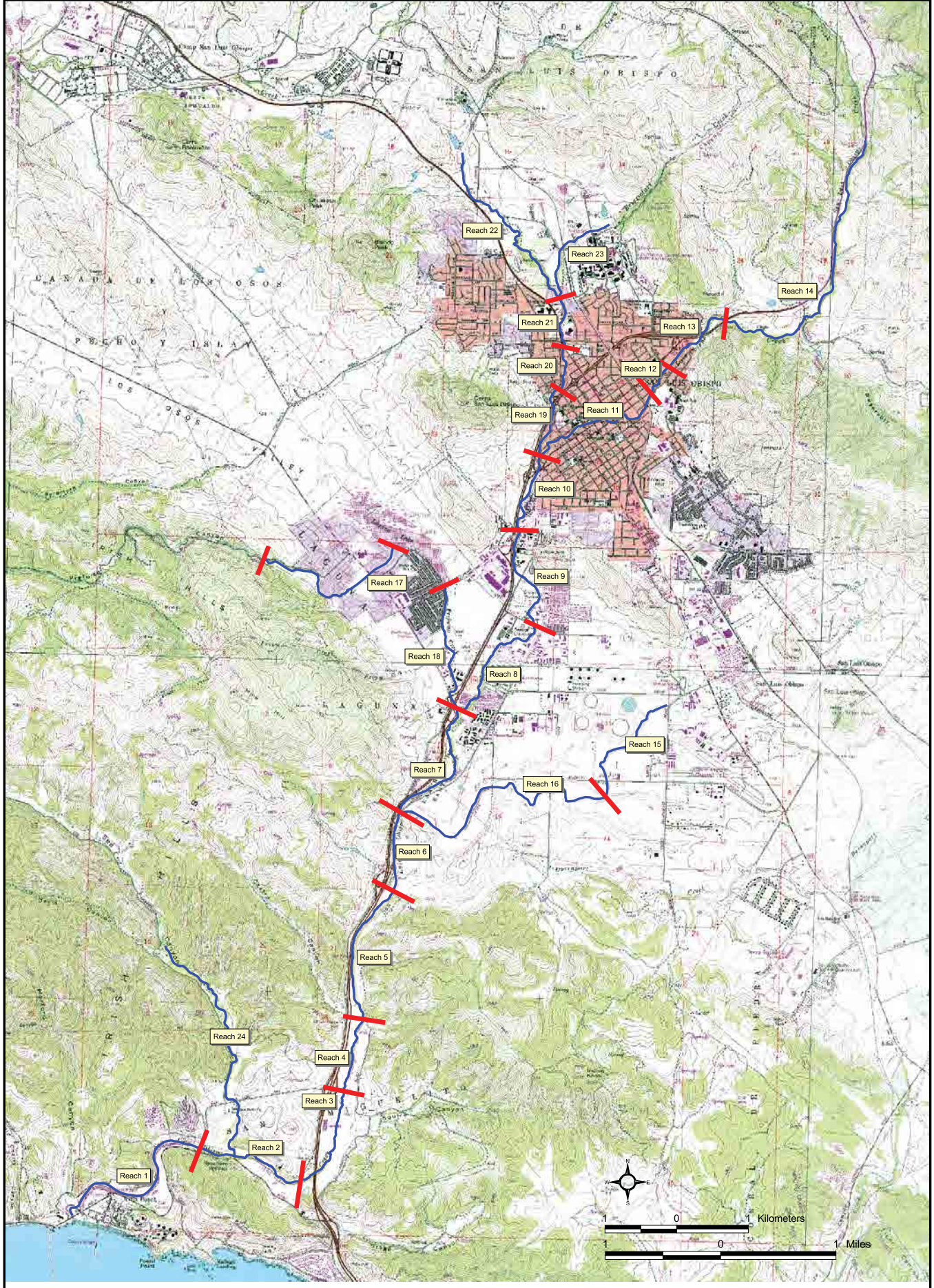
- San Luis Obispo and Arroyo Grande 15' sheets, 1897, 1916, 1952 editions

- San Luis Obispo, Pismo Beach, Arroyo Grande, and Lopez Mtn. 7.5' sheets, 1965, 1994 editions

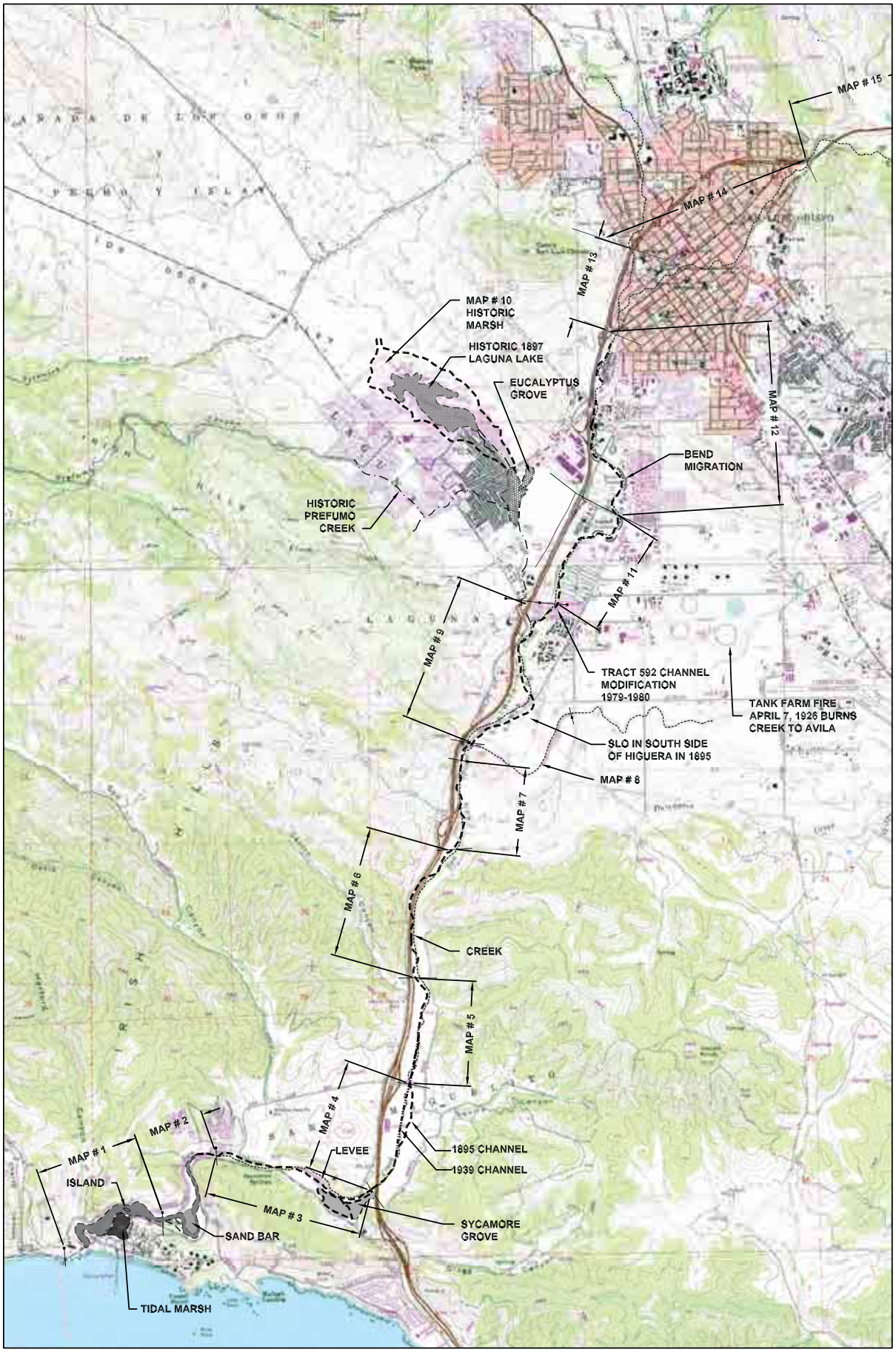
Aerial photography reviewed included 1939 photos from the US Army Map Service, 1955 & 1977 USGS photography, and 1996 photography from Golden State Aerial Surveys of San Luis Obispo. A summary of historical newspaper articles dating back to the 1870's and interviews with long- time residents of the watershed, prepared by the Central Coast Salmon Enhancement was also helpful in outlining the major events that have occurred in this watershed (Cleveland, 1996). Historic changes to the streams and the current conditions of stream segments are described for various reaches. **Figure 2-2** identifies the numbered stream reaches as used in this WMP. The stream reach designations were established by the Land Conservancy of San Luis Obispo County (Conservancy) in their 1996 hydrologic analysis report of the watershed. The map numbers indicated on **Figure 2-3** coincide with the numbering on **Table 2-1** summarizing the historic channel changes.

Table 2-1
Historic Channel Changes

Map Reference	Description
Location 1: SLO Creek at Avila Beach river mouth	(1) 1897: Lagoon mouth substantially larger and wider. Current lagoon appears to be reduced by approximately 1/3 (now 2/3) historic size. Large tidal marsh present to the east of the lagoon, under present location of western Avila Beach. (2) 1939: 1952: Lagoon geometry quite similar and relatively unchanged. (3) 1977: Lagoon constrained by Avila Bay Drive, similar to present configuration as shown on 1995 USGS topographic map.
Location 2: SLO Creek at San Luis Bay Golf Course	(1) 1897: Lagoon meanders to the south beneath present location of Golf Course. (2) 1939: Lagoon geometry changes are minor. (3) 1952: Lagoon meander becomes straightened to the north, although not quite as far to the north as apparent on 1965 edition of USGS 7.5' Quad of Pismo Beach (or the present alignment). (4) 1994: Golf Course now displaces the historic meander loop and sand-bar. Several islands depicted in 1965 map have disappeared. It appears that the original migration of the bend to the north was natural, but golf course construction made significant alteration. (5) 1995: Some concrete segments of bend appear to have failed.



city of san luis obispo	**LEGEND** Prioritization Reach Boundaries Stream Channel	**Stream Reach Map** **SLO Creek** **Waterway Management Plan** QUESTA ENGINEERING CORPORATION	**Figure** **WMP 2-2**



	Waterway Management Plan **Historical Channel Changes** QUESTA ENGINEERING CORPORATION	Figure WMP 2-3

Map Reference	Description
Location 3: SLO Creek below Sycamore Springs (between See Canyon and Gragg)	(1) 1939: Historic channel apparently 100-200 feet south of, but parallel to present channel; although scale and accuracy of original topo map makes this difficult to determine. Large Sycamore grove present. (2) 1952: Sycamore grove indicated as green shading. Similar shape as on photo. (3) 1977: Grove significantly reduced in size, remnant mainly along creek. Flood control levee constructed along channel in early 1970s, removing parts of the floodplain from connection with creek. Presently area now mostly in apple orchard, although some young Sycamores visible along channel.
Location 4: SLO Creek from Highway 101 Crossing to San Luis Bay Drive	(1) 1939: Historic channel 2-300 feet east of present channel. Historic channel shows fine meander pattern. Channel straightened and realigned to the west, largely devoid of vegetation in this reach. (2) 1965: Straightened alignment persisted and is apparent. (3) 1977: Some meanders become visible. Natural meander pattern re-exerting itself strongly within this straightened/aligned reach with significant natural willow re-colonization. (4) 1996: Apparent erosion of establishing channel bends observable. (5) 1995: Photo-revised location of SLO Creek in this reach shows re-establishment of same meander pattern as shown in original 19\895 survey. Floodplain appears active and frequently flooded in this area.
Location 5: SLO Creek from San Luis Bay Drive to Castro Canyon	(1) 1939: Channel apparently not significantly realigned in this reach. Natural channel meander pattern not apparent on photography and channel appears lines with willows. (2) 1950: Several of the channel bends straightened and line with broken concrete slabs associated with the widening of Highway 101.
Location 6: SLO Creek from Castro Canyon to near Davenport Creek	(1) 1950's: Several channel bends appear to have been straightened associated with Highway 101 construction. Channel and floodplain very active in this area, with several old channel meanders and traces of vegetated secondary channels apparent on photograph. This area appears to flood frequently. Several wet meadows apparent on floodplain to the east of the channel.
Location 7: SLO Creek from Davenport Creek to East Fork Creek.	(1) 1950's: Channel bends straightened and channel realigned associated with construction Highway 101.

Map Reference	Description
Location 8: Lower East Fork Creek	(1) 1895 (circa): Lower East Fork Creek apparently remained largely within its historic channel configuration, although no located 50 feet south. Earliest photographs show insignificant vegetation along channel. (Channel burned by explosion and fire at Tank Farm in April 1926. Burning oil fire reportedly carried along creek, destroying creek vegetation all the way to Avila). (2) 1970's: Upper section leveed and section near confluence with SLO Creek partially leveed in 1998. .
Location 9: SLO Creek from East Fork Creek to Prefumo Creek	(1) This section of SLO Creek changed significantly from historic (1897) conditions. SLO Creek on southeast side of South Higuera. Map indicates this section of the creek is intermittent, becoming perennial downstream of The Narrows, and upstream of Marsh Street. (2) 1939: Channel relocated to the north of Higuera; however the original trace of the channel still faintly visible. (Some problem with registration of the two maps here – so less certain). Channel well vegetated in this reach.
Location 10: Prefumo Creek and Laguna Lake area	(1) 1897: Laguna Lake historically smaller in size, with open water area terminating approximately 3000 feet northwest of Madona Road. Large wetland shown by symbols on map, surrounding Laguna. (2) 1952: Lake similar in size and shape. Laguna Lake deepened to present shape by mid-1960s. Apparently small area of wetland filled on southwest shore, but deepening predominantly within limit of what was historic marshland. (3) 1965: Lake extended further northwest, but this may be an artifact of the time of year and rainfall; as the shape of this shallow lake and wetland area can vary seasonally. This area may have been a major natural flood water detention area, as black marsh soils extend in a large area surround Laguna Lake. (4) Prefumo Creek originally shown as flowing through present day Shopping Center to join SLO Creek in large Eucalyptus grove below Laguna Lake outlet. Grove is present in 1939 photographs. (5) 1960's: Prefumo Creek re-routed through City Golf Course. Channel gradient too steep and area is experiencing bed incision and bank erosion. Several drop structures installed to arrest bed erosion; some are minor fish passage obstacles.
Location 11: SLO Creek from Prefumo Creek to Prado Bridge	(1) 1979-1980: This area significantly altered by major channel modification and flood control project (Tract 592). Channel significantly widened with a compound channel. Channel now experiencing erosion of some channel bends, and aggradations of in-channel willow covered terrace. Channel bends along portions of this reach protected with gabions, rip-rap, and other hard bank protection devices.

Map Reference	Description
Location 12: SLO Creek from Prado Bridge to Marsh Street Bridge	(1) This apparently is an unstable section of the creek, where the channel has been realigned associated with the historic construction of Highway 101. Elevated fill for Hwy 101 construction partially isolated historic floodplain on the west side of the creek. Several sharp channel bends were re-graded and the channel lined in some sections, particularly at Madonna Road associated with interchange construction in the 1960's. This is also a flood prone section of the creek.
Location 13: SLO Creek from Marsh Street Bridge to Santo Rosa Street Bridge	(1) 1916: Portions of this section of SLO Creek underground. Under-City culvert indicated. (2) Channel straightened and largely within present alignment, confined by bank protection devices at many channel bends.
Location 14: SLO Creek from Santa Rosa Street Bridge to Highway 101 at Cuest Park	(1) Channel remains largely within existing historic alignment from the 1890's. (2) 1939: Channel appears to be well vegetated with willows. (3) 1977: Streamside tree cover appears less dense, following reported period of channel clearing in response to floods of 1969 and 1973. Although not directly observable on aerial photographs, removal of tree cover and other flow obstructions are through to have contributed to rapid channel down cutting during the late 1970's through present, as stream flow velocities increased. This resulted in local bank failures, particularly at channel bends. Several historic channel retaining walls built in the 1950's and 60's have collapsed as their footings have been undermined by the incising channel.
Location 15: SLO Creek from Cuest Park to Cuest Grade (including Reservoir Canyon confluence)	(1) At map scale shown, channel alignment largely unchanged, few channel bends, except where canyon tributaries join main stem of creek. (2) 1897 USES Survey: Southern Pacific Railroad over Cuesta Grade indicated, along with water supply reservoir on Reservoir Canyon. Dirt access roads for railroad maintenance not shown.

Until the 1770s when the Spanish established the Mission of San Luis Obispo, the SLO Creek watershed was relatively undisturbed. Although the Chumash Indians inhabited the region for thousands of years prior to the Spanish settlement, their hunting, fishing and gathering lifestyle did little to alter the creeks. Under the Spanish, however, wheat farming and cattle and sheep ranching were intensive, and altered the region's hydrology, probably permanently.

By 1846, the government had secularized the mission's land, transferring it to private ownership and establishing more than 30 land grants, or ranchos, in San Luis Obispo County. Severe droughts in the late 1860s forced rancho owners to sell off portions of their lands. San Luis Obispo became a county of small farms and sheep and cattle ranchers. The population began to increase and the economic base began to change with the establishment of the railroad. The Southern Pacific Railroad completed its line from San Francisco to San Luis Obispo in 1884. Major hillside cuts were required in the Cuesta Grade area to accommodate the railroad tracks.

Much of the natural vegetation along SLO Creek was apparently removed by farming and grazing during this early period. In fact, many of the old photographs and artists sketches dating from the 1880s in the Historical Society Museum in the City show the stream bank tops as largely barren. Over the past century, urban development encroached upon the SLO Creek. This resulted in periodic exposure to flooding of structures located along creek banks, and increased flood damages. Damaging floods are reported to have occurred in 1861, 1862, 1884, 1897, 1911, 1948, 1952, 1962, 1973, and 1995. The 1861-62 floods were reported to have removed many of the mature sycamore trees (which may have been hundreds of years old) along large portions of the upper and middle reaches of the creek (Cleveland, 1996).

A lighting strike caused a fire in August 1926 at the Union Oil Tank Farm located in the present Airport Area of the East Branch of SLO Creek drainage. The strike ruptured a large tank and sent a stream of burning oil down East Branch to San Luis Obispo Creek. The burning oil reached Avila Beach. Nearly all of the mature woody vegetation was apparently destroyed from the creek between East Fork and Avila by this fire. A period of severe bank erosion apparently followed the fire and loss of protective vegetative cover.

Channelization, including straightening of creek meanders and realignment for farming and road and highway construction has also been common within the SLO Creek watershed. The lower estuary areas appear quite different on the 1877 topographic maps from those of the 1994 editions, with the extent of the estuary and marsh significantly smaller and several large gravel bars greatly diminished in size. The creek was apparently realigned in this area several times for road construction and for construction of a golf course in the 1970s.

In 1969, the Luigi Marre Land and Cattle Company constructed an approximately 1-meter high sheet-pile dam across the lower SLO Creek approximately 1.5-km above its mouth. (Morro Group, 2002). The reported purpose of the dam was to halt upstream saltwater intrusion into the underground aquifer of this area. This dam, constructed in the turn of a stream meander, also has significantly affected stream conditions in this area, including channel shape, pool formation below the dam, fine sedimentation upstream, and reduced salinity of the channel above the dam. (Upper Salinas River-Las Tablas Resource Conservation District, Dec. 2001) Although a fish ladder was constructed shortly after dam construction, the ladder has been ineffective, and the dam has changed the habitat conditions for the Tide Water Gobby, an endangered species that occurs in the lower estuary area.

The lower segment of SLO Creek in Reaches 4&5, (above Marre Dam) were apparently straightened for more efficient farming some time in the 1930's as the previous slight meander pattern of the channel in this segment was replaced by a straightened section, as shown on 1939 U.S. Army aerial photography and the 1952 U.S. Geological Survey topographic map of the quadrangle. Levees were also constructed along the creek in the lower part of this reach some time in the 1970s.

Major channel meander straightening and realignment took place along much of SLO Creek in the mid to late 1950's, associated with construction of Highway 101. The stream reach just upstream of the South Higuera off-ramp to Hi101, and the reach just below this, to the Narrows below Davenport Creek (Reaches 5, 6&7) were apparently realigned during this period, with portions of the west bank protected by riprap and concrete slabs. The realigned creek has a steeper gradient in this area than historically and has incised into the channel bed several meters.

Some channel realignment also took place between the Marsh Street Bridge and Madona Road (Reach 10) during this time period, associated with Highway 101 construction. The Highway was also elevated on fill in this section, more or less disconnecting the floodplain on the west side of Highway 101 from all but the most significant flooding. This fill likely exacerbated the already frequent flooding in the Mid-Higuera area. The floodplain had already been significantly encroached upon by fill placement and buildings on the east (South Higuera Street) side associated with more than 100-years of commercial use of this area. The channel modifications also apparently affected downstream channel segments, and portions of the channel were lined in the vicinity of the Caltrans yard and above the cemetery in the Elks Lane area (Reach 9).

The Laguna lake area appears somewhat similar when comparing the 1897 and 1994 editions of USGS topographic maps. The Lake itself is slightly larger, but the wetlands surrounding the lake are smaller, due to filling in the 1960's and 1970's for residential development. Prefumo Creeks was re-routed through Laguna Lake and an outlet control structure was installed.

SLO Creek and its tributaries, including Meadow Creek, Stenner Creek, and Old Garden Creek have undergone significant channel modifications by private property owners prior to the period of state highway construction, dating back to at least the 1920's. This included straightening associated with city block street layout, undergrounding of portions of Old Meadow Creek, and construction of a haphazard assortment of bank revetments and channel lining by private property owners along the creek.

The Under-City culvert, which passes SLO Creek flow through the downtown area between Chorro and Marsh Streets was apparently under-grounded sometime in the early 1900's, in part because of water quality and odor problems from the period when the creek was more or less used as part of the sewer system.

The early City also relied upon a series of dams and water diversions for its water supply. This included construction of the Stage Coach Dam on upper SLO Creek prior to the turn of the Century, and construction of Reservoir Canyon on the Reservoir Creek tributary circa 1911. These and other smaller, earlier dams constructed upstream of Stage Coach Dam virtually stopped the transport of all larger bed-load (gravels and cobbles) downstream. Such a disruption in sediment supply typically results in channel downcutting as the stream readjusts to a diminished sediment supply.

There is almost no evidence of the existence of the early small dams on upper SLO Creek. Stage Coach Dam, which is about 4 meters high, represents an almost insurmountable barrier to fish passage. (This dam is now completely filled in with large cobbles, and will be removed by the City under a grant from the California Department of Fish and Game in the fall of 2002, or summer of 2003).

The only major flood control project constructed within the watershed is located above the Los Osos Valley Road Bridge in Reach 8. In 1978, as part of the Tract 592 subdivision to the east of SLO Creek, a private developer channelized SLO creek to protect future development from the 100-year flood. The channelization consisted of excavating one of the channel banks (alternating east and west) to form an in-channel floodway terrace, leaving the existing channel bottom largely in its natural state, and revegetating the newly formed banks. The terrace is now densely vegetated with shrubby willows.

The most recent floods in 1995 followed an unusually a wet three-month period, January through March, which was reportedly the wettest period in 116 years of record. The stream banks remained saturated for months and were repeatedly attacked by moderate to high flows. The impacts of the 1995 flood were made more severe by the Highway 41 fire. A major portion of the Upper Stenner, Brizziolari and SLO Creeks west of Cuesta pass was burned in 1994. The denuded watershed responded to the 1995 storms with increased rates and volumes of runoff and significant movement of sediment into the lower channels. The 1995 storms were particularly devastating to channel conditions, because a series of storms swept through the area, resulting in prolonged high-flow, high velocity events, giving little time for the channel to recover and dry out between flood events. While the sediment input is returning to pre-fire conditions, the increased sediment discharge is anticipated to persist for many years. Creek flow may be re-mobilizing and re-working the sediments deposited earlier in the headwater channels, as well as along the bars throughout the main channel within the lower valley.

Many of the problems in the SLO watershed appear to have been caused by historic land uses, especially dirt access road for utility construction and maintenance, and railroad construction in upper watershed areas. The main impact of urbanization in this watershed appears to be its effect on increasing the 2-year or channel forming flow, and resultant channel instability concerns. The small dams in the upper watershed may also have had an effect on channel stability, by removing an important source of coarse sediment, thereby causing channel down-cutting and further bank instability

2.8 Existing Channel Conditions

The deeply incised character of SLO Creek today is evidence of the creek's response to the historical hydrologic changes noted above. Increased discharges from urban areas and grazing lands result in higher velocities that are capable of eroding the channel bed and banks. Erosion continues until the slope reduces to adjust to the changes in hydrology. In addition, dense creek-side vegetation, which had previously provided bank stability, was reduced in many areas during urbanization and encroaching agricultural uses, accelerating the erosional process. The channel response to the increased flows and sediment loads particularly following the 1994 fire and 1995 flood has been to widen its channel through bank erosion in flatter areas or areas underlain by harder claystone, and to incise, and scour in areas of steeper gradients or having softer bottoms. In reaches with meanders, the meanders typically are migrating (slowly) downstream, often impinging on the left bank, probably reflective of the tilt of the valley. As previously noted, stream realignment and straightening for agricultural purposes and for street and highway construction have also had a significant effect on the stability of the streams, as has the haphazard construction of bank lining and revetments which have moved problems cross-channel and downstream.

2.9 Channel Hydraulics and Stability Analysis

New computer models of the rainfall/runoff hydrology of the watershed (HEC-HMS model) and the channel hydraulics of the major streams and floodplains of the watershed (HEC-GEORAS model) were developed as part of the planning process (see **Appendix C**). These were used to help identify channel constrictions and flood prone areas, as well as areas where high channel velocities and shearing forces can attack unprotected and over-steepened channel banks. High and erosive stream velocities were found to occur in the upper watershed area of Reach 14, (in the Cuesta Grade area) as well as locally within reaches 9 and 10 (upstream of Prado Road to above Marsh Street). The highest shearing forces occur at the toe of the bank on the inside of channel beds. The computer models were also used to develop and test alternative methods to address the identified flooding problems.

The hydrologic/hydraulic analysis found that since development of the watershed the amount of flow in SLO Creek during the 100-year flood event has only increased a few percent (since the early 1960's), but the 2-year channel shaping flow has increased by as much as 10-12 % near the Mid-Higuera area. The hydrology and hydraulics models will also be useful for future site-specific planning in the watershed to insure that new development does not increase flooding and bank erosion problems, as well as to test the design of individual bank repair and flood management projects. Modeling methods and procedures are contained in the report entitled *Hydrology and Hydraulic of the SLO Watershed.*

2.10 Watershed Perspective on Channel Stability

Evaluations of channel bank erosion and other fluvial geomorphic processes included completing a detailed Global Positioning System (GPS) assisted field inventory of the main stem of SLO Creek and its tributaries, and studying historic maps and aerial photography.

San Luis Obispo Creek has undergone system-wide channel bed incision throughout much of its course, in places experiencing as much as 1.5 to 3 m (6 to 10 ft) of downcutting. The hydrologic analysis completed indicates that the incision is likely the result of increases in the volume of the two-year channel forming flow from urbanization of the watershed, combined with the extensive turn of the century livestock grazing that damaged watershed lands and has permanently increased runoff rates. Creek straightening and realignment associated with street and highway construction have also had significant effects on the stream system, by shortening and steepening reaches, increasing stream velocities. The haphazard placement of various bank protection structures has also created local instabilities. The hydrologic analysis showed relatively minor increases in the 50-year and 100-year recurrence interval flood flows (less than 2% increase).

2.11 Reach Descriptions (*refer to Figure 2-2*)

- **Reach 1** extends from the mouth of SLO Creek at Avila Beach to the San Luis Bay Drive Bridge, flowing past the San Luis Bay Drive Golf Course. Avila Drive is located on the south side in this reach. This reach is tidally influenced. The Marre Dam forms a barrier to tidal flow upstream, and blocks creek flow. Since it is an apparent obstacle to steelhead passage, (it includes an inefficient fish ladder) the Land Conservancy has a proposal to modify it. The channel banks are highly eroded along the golf course, and many areas failed during the flooding of 1995, including the loss of two pedestrian bridges.

- **Reach 2** extends from San Luis Bay Drive to the Ontario Street Bridge near Highway 101. This area has mature riparian vegetation, including large Sycamores and the banks are generally in good condition.

- **Reach 3** extends from the Ontario Road Bridge under the Highway 101 Bridge to the San Luis Bay Drive Bridge. This area is mostly agricultural, including an extensive apple orchard planted along both sides of the creek. Although the downstream end of this reach has mature riparian vegetation, most of the reach has dense young willow growth. Portions of this area was cleared and straightened in the late 1930's, and agricultural practices kept the channel banks mostly clear of willows until the last 10 to 15 years. The corridor is faily narrow and lacks diversity.

- **Reach 4** extends from the San Luis Bay Drive Bridge east of Highway 101 to a wooden agricultural access bridge crossing of the creek. The lower section is mostly young willow trees, while the upper section of the reach has a more structurally and species diverse assemblage of riparian plants. The riparian corridor is fairly narrow. Willows have become established on bars in the stream channel in this reach, forcing flow against the banks and causing extensive erosion. In part, this is a natural process as the stream regains its natural tendency to meander in a section that was lost when the channel was straightened in the late 1930's. Roads and structures are not threatened, and there are numerous pools with good cover. In places, concrete slabs have been placed

haphazardly along the banks in an attempt to arrest erosion. These have been largely ineffective, and may be causing problems locally where flow is constricted.

- **Reach 5** is a reach between two private farm access bridges, to the Bunnell parcel on the south and the Maino parcel on the north. This reach has a generally good mix of riparian species of differing areas. However, the east bank top in one section is lined with Monterey Pines. Several of these have toppled into the creek in the past, and a number are undermined and in danger of toppling. This reach was also modified and realigned during the construction of Highway 101 in the 1950s. The channel is downcutting in this section, contributing to channel bank instability on the east bank. The west side was partially lined with broken concrete slabs, presumably when the highway was constructed, although many have been partially overgrown by willows. A small drop structure was apparently constructed in this reach at one time to arrest further channel bed incision. This structure is beginning to flank and is in danger of failing at some point in the future. Davenport Creek enters the channel in this reach from the east. Since the main channel has incised in this reach, channel headcutting is now working its way up Davenport Creek.

- **Reach 6** extends from the Maino parcel bridge to the bridge at the South Higuera Street on-ramp to Highway 101. This reach was also realigned during construction of Highway 101, and has a zone of almost continuous bank erosion on the west bank. East Fork enters the creek on the east side. The lower portion of East Fork was recently stabilized and enhanced in a cooperative project among the City, County, and Land Conservancy. Although some enhancement has been completed through this reach, there are opportunities for additional enhancement and stabilization where the creek parallels south Higuera.

- **Reach 7** extends between South Higuera Street and Los Osos Valley Road. It has a fairly continuous riparian cover. Bank erosion is occurring at channel bends, some of which have been stabilized recently by the Land Conservancy using biotechnical methods.

- **Reach 8** is a 2 km stretch between the Los Osos Valley Road Bridge (at the southwestern corner of the San Luis Obispo City limits) and the Prado Road Bridge. A large bend, with a steep near vertical bank, occurs just downstream of Prado Road. From the Los Osos Valley Road bridge to the City's wastewater plant (WWTP) the channel is a 40-meter wide floodplain that was constructed in the 1970s for flood control. San Luis Creek makes a sharp bend upstream of the Los Osos Valley Road Bridge. There is a wide low dense willow thicket floodplain on the east side where sediment is accumulating. The floodplain terrace is about three meters above the channel bed. On the west side, Prefumo Creek joins SLO Creek about 100 meters upstream of the Los Osos Valley Road Bridge. The City's WWTP discharge point is upstream of the confluence with Prefumo Creek. This area was enhanced in 1999 as mitigation for bank repair projects completed at that time.

- **Reach 9** is a 1.5-km. stretch between the Prado Road Bridge and the Madonna Road Bridge. In this area, SLO Creek makes a sharp bend. The outside of the bend is partially covered by broken concrete slab rubble. This rubble and small cement slabs downstream are being undermined at the toe, evidence that the river may be actively downcutting in this stretch. There is a 400-meter stretch downstream of the Elks Lane Bridge that is a straight, well-vegetated trapezoidal-like earthen channel. The banks in this stretch are significantly lower than other sections of the creek.. On the downstream side of the Elks Lane Bridge, the west bank steepens and is encroaching upon a small trailer park. Between the Elks Lane Bridge and the Madonna Road Bridge the creek meanders within a deeply incised channel, with bare vertical banks up to four meters high along the outside of the bend. On the inside of the bends are gravel bars with various degrees of willow colonization. The east bank of the remaining 200 meters of Reach 9 is actively eroding and threatening the Caltrans maintenance facility; although, some repair Caltrans completed work here in 1998. Directly downstream of the Madonna Road Bridge both banks are protected by a 30-meter long concrete slab. The east bank is partially protected for another 20 meters downstream by boulder rip-rap.

- **Reach 10** is a 1.2-km stretch extending from the Madonna Road Bridge upstream to the confluence with Stenner Creek. This reach was also surveyed in 1997 as part of the Phase I studies. For 125 meters upstream of the Madonna Road Bridge the steep west bank is being undercut at the toe, potentially threatening the Highway 101 roadway base fill. Moving upstream, the outside of the next meander bend is protected by a mixture of rip-rap, gabions and grouted rock. Upstream of this is a 100-meter stretch of relatively undisturbed channel before the creek bends back to the east. The outside of this bend, which is protected by sackrete, runs closely along side Highway 101. The west bank on the upstream edge of the sackrete is over-steepened and could result in gradual failure of the sackrete.

  The Hayward Lumber yard, which was repaired in 1999 as part of the Phase I program is 180 meters upstream of the sackrete wall. Approximately 50 meters upstream of the Hayward Lumber is the Bianchi Lane Bridge. On the west bank directly upstream of this bridge, there are a series of culverts that empty into the creek from the top of the bank. The flows from these culverts are creating gullies, which will continue to widen and may eventually jeopardize the bridge foundation. Between the Bianchi Bridge and the Marsh Street Bridge upstream, the channel is straight with steep moderately vegetated banks. Portions of the west bank in this 200-meter stretch show signs of incipient erosion. Between the Marsh Street Bridge and the confluence with Stenner Creek, SLO Creek passes under another small bridge and through a straight stretch of well-vegetated trapezoidal channel. Channel gradient steepens in this area.

- **Reach 11** extends from the confluence of Stenner Creek to the California Street Bridge at San Luis Bay drive. This is the Mission Plaza and downtown area. The under city culvert occurs in this reach, extending from just below Chorro Street to just below Marsh Street. The banks throughout this reach are mostly lined, including stacked concrete, gabions, and rock walls.

- **Reach 12** begins at the California Street Bridge and extends to the Andrews Street Bridge. This reach extends primarily through residential properties, many of which have built up to the top of the creek bank. Much of the banks in this section have been lined, some with vertical retaining walls. However, the creek channel is continuing to incise in this reach, potentially undermining some of the structures. In other areas, banks are largely barren and unprotected and subject to erosion.

- **Reach 13** extends from the Andrews Street Bridge to the Highway 101 culvert at Cuesta Park. This area is primarily residential, but with some commercial office buildings located along the creek banks. Several sections of this reach have been stabilized with gabion baskets and other "hard" bank protection structures.

- **Reach 14** extends 2.5 kilometers upstream from the Highway 101 culvert above Cuesta Park. Upstream of the Highway 101 culvert, the channel is relatively undisturbed with low, well-vegetated banks and frequent bedrock outcrops. The bed material is primarily cobbles with gravel and sand point bars. Moving upstream, the channel bends gradually to the north with a bare and vertical north bank. Inside of the bend, there is a wide cobble and sand bar, which rises gradually into a grass field. Many of the mature Sycamores in this reach are being undermined and are in danger of falling into the creek.

  Between Cuesta Park and the Reservoir Canyon Bridge, the channel is deeply incised with banks up to six meters high. SLO Creek is joined by Reservoir Canyon Creek from the south. The channel has steep banks, which are actively eroding at the toe, on the outside of the meander bends. The inside of the bends are cobble point bars below more stable partially vegetated banks. About 200 meters upstream of the City's Pistol Practice Range, the toe of a large landslide encroaches on the channel. This potential failure could contribute a great deal of sediment and large woody debris to the creek, which might cause log jams downstream and contribute to flooding problems.
  The Reservoir Canyon Bridge is located in the middle of a sharp bend in the creek. Bank protection measures undertaken at the bridge in 1998 include rock rip-rap and concrete. Approximately 100 meters upstream of the bridge the south lower bank is lined with concrete rubble below a large private home. Upstream of this home is a natural bedrock falls, which drops approximately one meter from a pure bedrock channel to a mixed bedrock and gravel channel downstream. The lower south bank is predominantly bedrock while the upper bank is gently sloping and moderately vegetated. On the north side are steep bedrock banks up to five-meters high. Upstream of the bedrock, the primary direction of flow of SLO Creek shifts from east-west to north-south.

  For the last 300 meters SLO Creek flows alongside Highway 101. There are several large culverts, which flow under the highway and drain into the creek. The final 200 meters is a straight narrow channel with one to three-meters high banks. The west bank along Highway 101 is lined with sackrete. The lower east bank is bare with many exposed roots, while the upper bank is well vegetated with large trees, including a mixtures of Eucalyptus and Sycamore. These are in danger of toppling into the creek with on going bank erosion.

- **Stenner Creek (Reach 19, 20, 21, 22).** The Stenner Creek reach begins at the confluence with the main stem of SLO Creek and extends 700 meters upstream to the Highway 101 Bridge. 100 meters upstream of the confluence, the west bank is claystone bedrock with a well-vegetated upper bank. Upstream east bank is a concrete floodwall, lined on the bottom with concrete rubble. The bank opposite the floodwall is well vegetated and gently sloping. Downstream of the concrete rubble is a scour hole exposing tree roots. Severe erosion is threatening a historic black adobe building.

  Near the Nipomo Street Bridge there are a variety of channel protection measures implemented by individual property owners. These include concrete and boulder rip-rap and cemented boulders, some of which show evidence of toe scour. There are large pieces of concrete debris, which indicate partial failure of the bank protection. Individual culverts drain into the creek with inadequate outfall protection.

  Between the Nipomo Street Bridge and Highway 101, the channel is straight and trapezoidal-like with moderately vegetated banks. The lower banks are covered primarily with grasses and willows, while the upper banks are covered with ivy and larger, mostly exotic trees. In this 300-meter stretch, there are patches of bank protection including concrete and boulder rip-rap. The bed material is gravel and cobbles with large chunks of concrete debris from failed bank stabilization efforts.

- **Prefumo Creek (Reach 17 –18).** The Prefumo Creek reach extends 950 meters upstream from the Los Osos Valley Road Bridge through the Laguna Lake Golf Course to the upstream edge of a trailer park. The channel in the lower half of this reach is primarily a grass trapezoidal channel. Between the Los Osos Valley Road Bridge and the first golf cart bridge, the trapezoidal channel has several small soil slips. Within this 240-meter stretch, there are three small concrete drop structures and one concrete ford before the creek drops under the Los Osos Valley Road Bridge.

  Upstream of the second bridge is a small grouted rock drop structure and gabion wall, with a north bank that is steep and poorly vegetated. At the upstream edge of the gabions, Prefumo Creek makes a sharp bend and a small tributary comes in from the south. For most of the final 320 meters of the reach, Prefumo Creek runs through a primarily undisturbed channel along the base of a steep hillside on the south and a trailer park on the north. The banks are moderately vegetated with a few short bank protection measures undertaken by individual property owners.

3. PROBLEM IDENTIFICATION AND WATERWAY MANAGEMENT NEEDS

3.1 Introduction

his section of the WMP discusses resource management problems, management needs, and restoration and enhancement opportunities that currently exist along SLO Creek and its principal tributaries. A separate part of this section discusses the flooding problems along SLO Creek and its main tributaries. Identification of resource problems and management needs is based on previous surveys completed as part of the SLO Creek Phase I report; planning studies completed by the Land Conservancy in 1996 (as part of a watershed hydrologic survey); this Phase II biologic and stream geomorphic inventory; detailed hydrologic and hydraulic modeling completed for the WMP, and a watershed reconnaissance.

3.2 Watershed Reconnaissance

A reconnaissance investigation of the watershed was completed to determine the principal management issues facing upland areas of the watershed. The reconnaissance was done after studying the previous *Land Conservancy Watershed Hydrologic Analysis* (1996) and reviewing a set of black and white stereo-paired aerial photography of the watershed, as well as select low altitude color photography of the watershed, focused on creek corridors.

The watershed reconnaissance and literature revealed:

- Turn-of-20th century and prior to that period intensive grazing (and in places overgrazing) led to changes in the rainfall-runoff dynamics of upland areas, including displacement of perennial grasses with annual grasses, soil compaction, and higher peak runoff rates. This has likely led to the stream incision or channel bed downcutting that is common throughout all of the creeks in the watershed.

- The effects of fire suppression in this watershed are not fully known, but the periodic large fires in the watershed (e.g.1994 Highway 41 fire) delivered high sediment loads, some of which are still working their way through the fluvial system. This may have contributed to the 1995 winter flooding, as runoff rates in fire areas are known to be higher, with much larger delivery of sediment to stream channels that reduce the flow carrying capacity of the streams.

- There are significant historic barren railroad grade cuts in the Cuesta Grade area. In some locations where the railroad or dirt access roads cross small tributaries, culverts have been installed which have unprotected having discharge points. These generate significant sediment loads to the upper creek system. Dirt utility access/maintenance roads also appear to be secondary contributors to upland erosion in some areas.

- Several historic water supply dams have been constructed in the upper watershed area, including a small dam near Stage Coach Road, and the larger Reservoir Canyon facility.

These structures trap bed load sediment (cobbles and large gravels) and remove a portion of the sediment load from the fluvial system. The loss of bed load can also result in stream incision as the channel responds to this loss by eroding stream bottom materials.

- Overall, the watershed appears to be in fair to good condition, compared to other coastal area watersheds in central California, because upland erosion, gullying and active landsliding areas are not extensive. The upper Prefumo Creek watershed and the Prefumo Canyon area is the sub-basin with the most significant upland erosion and stream-side landsliding and slope instability problems.

- Based on watershed reconnaissance and observations and the work completed by the Land Conservancy, it appears that most of the sediment yield entering SLO Creek is presently coming from erosion of secondary channels and the main SLO creek channel, not from watershed upland erosion.

- Based on the results of the hydrologic analysis completed for the Phase II studies, it appears that urban development since the 1960's have not had a significant effect on flooding. However, urban development has affected the 2-10 year channel-forming flows more than 25, 50 & 100- year flood flows. This may be important in a watershed where channel capacity is limited to the 20-25 year recurrence interval range. Increased flows at lower storm return intervals (e.g. increased 2-year channel forming flow) can cause channel incision and toe scour, which in turn can cause widespread bank failure.

3.3 Problem Identification

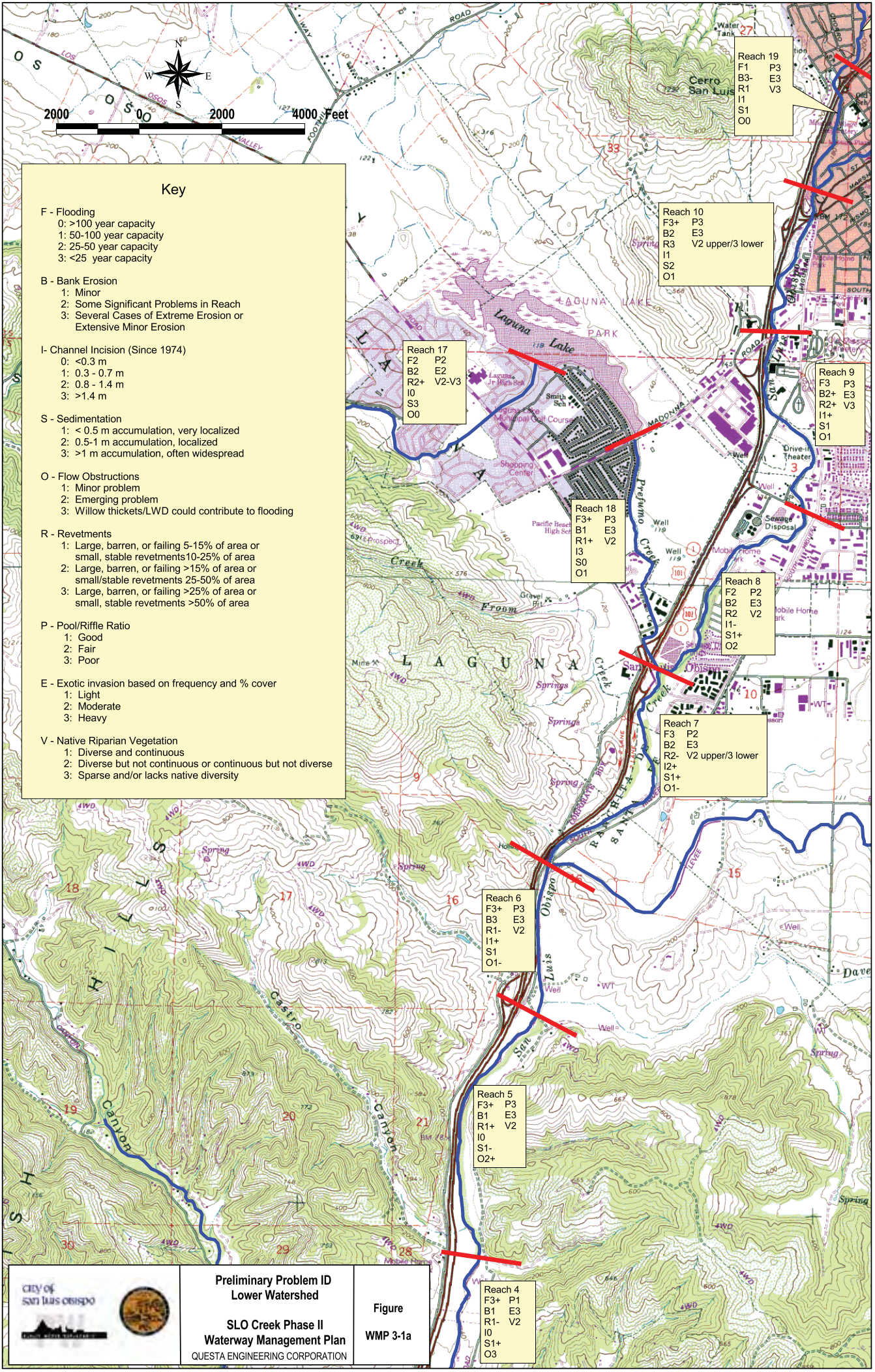
The main channel of SLO creek (and main tributaries) was divided into 14 reaches in the Conservancy study. Their reach numbering system was used for this WMP. East Fork SLO Creek was assigned Reach 15.

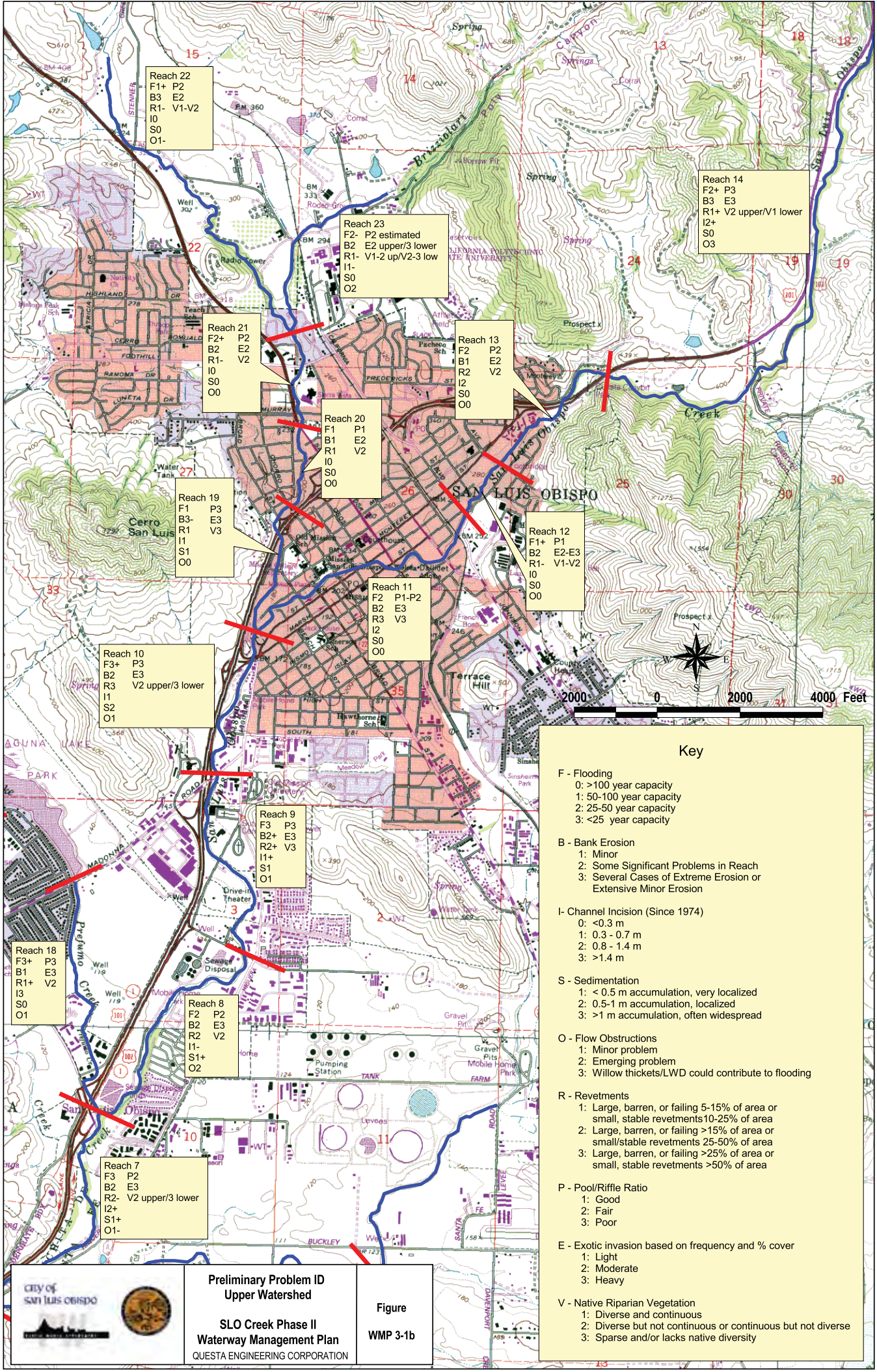
Figures 3-1A and 3-1B present Problem Identification maps. The maps identify and summarize the following problems and management needs:

- **Flooding**; whether flows are out of bank or not in the 10, 25, or 50 or 100-year-flood recurrence interval flow conditions.

- **Bank Erosion**, based on the field inventory.

- **Channel Bed Erosion**. This was determined by comparing the 1974 City surveyed cross-section geometry bed elevations used in previous FEMA hydraulic model with the LiDAR acquired channel topography. Adjustments were made for differing datums. Areas of active channel incision were also noted in the field based on exposure of culvert inverts and bridge abutments, and foundation lines of historic channel retaining walls and revetments. Creek bed incision can lead to undermining and collapse of retaining structures, and extensive bank erosion as new channel banks become over-steepened and too high for the natural soil foundation conditions to support.


N
W
E
S
2000
0
2000
4000 Feet
Key
F - Flooding
0: >100 year capacity
1: 50-100 year capacity
2: 25-50 year capacity
3: <25 year capacity
B - Bank Erosion
1: Minor
2: Some Significant Problems in Reach
3: Several Cases of Extreme Erosion or Extensive Minor Erosion
I- Channel Incision (Since 1974)
0: <0.3 m
1: 0.3 - 0.7 m
2: 0.8 - 1.4 m
3: >1.4 m
S - Sedimentation
1: < 0.5 m accumulation, very localized
2: 0.5-1 m accumulation, localized
3: >1 m accumulation, often widespread
O - Flow Obstructions
1: Minor problem
2: Emerging problem
3: Willow thickets/LWD could contribute to flooding
R - Revetments
1: Large, barren, or failing 5-15% of area or small, stable revetments10-25% of area
2: Large, barren, or failing >15% of area or small/stable revetments 25-50% of area
3: Large, barren, or failing >25% of area or small, stable revetments >50% of area
P - Pool/Riffle Ratio
1: Good
2: Fair
3: Poor
E - Exotic invasion based on frequency and % cover
1: Light
2: Moderate
3: Heavy
V - Native Riparian Vegetation
1: Diverse and continuous
2: Diverse but not continuous or continuous but not diverse
3: Sparse and/or lacks native diversity
Reach 19
F1 P3
B3- E3
R1 V3
I1
S1
O0
Reach 10
F3+ P3
B2 E3
R3 V2 upper/3 lower
I1
S2
O1
Reach 17
F2 P2
B2 E2
R2+ V2-V3
I0
S3
O0
Reach 9
F3 P3
B2+ E3
R2+ V3
I1+
S1
O1
Reach 18
F3+ P3
B1 E3
R1+ V2
I3
S0
O1
Reach 8
F2 P2
B2 E3
R2 V2
I1-
S1+
O2
Reach 7
F3 P2
B2 E3
R2- V2 upper/3 lower
I2+
S1+
O1-
Reach 6
F3+ P3
B3 E3
R1- V2
I1+
S1
O1-
Reach 5
F3+ P3
B1 E3
R1+ V2
I0
S1-
O2+
Reach 4
F3+ P1
B1 E3
R1- V2
I0
S1+
O3
Cerro San Luis
Laguna Lake
Prefumo Creek
San Luis Obispo Creek
Froom Creek
Castro Canyon
Laguna Lake Municipal Golf Course
Shopping Center
Pacific Beach High Sch
Sewage Disposal
Drive-in Theater
Mobile Home Park
Water Tank
Well
Spring
Springs
Gravel Pit
Mine
Prospect
Levee
Dave
city of san luis obispo
Preliminary Problem ID
Lower Watershed
SLO Creek Phase II
Waterway Management Plan
QUESTA ENGINEERING CORPORATION
Figure
WMP 3-1a



city of san luis obispo

Preliminary Problem ID
Upper Watershed

SLO Creek Phase II
Waterway Management Plan
QUESTA ENGINEERING CORPORATION

Figure

WMP 3-1b

- **Sedimentation**, or the accumulation of sediment in the channel or under bridges. This also was based on field notes and comparisons of the FEMA profile with the LiDAR (airborne laser elevation survey) topographic data. Usually, but not always, sedimentation is observed as isolated sand and gravel bars, particularly at channel bends, or accumulations under and near bridges. Accumulation of sediment in a channel can reduce the flood flow carrying capacity of the channel or bridge section, and can clog or fill spawning gravels and shallow pools that form important aquatic habitat.

- **Flow Obstructions**. This was based on a review of the field inventory data and inspection of aerial photography. This is a more subjective determination, but has been assisted by hydraulic modeling to determine where debris jams and dense willow thickets can materially affect channel flood flow capacity.

- **Revetments**. This was also based on the field inventory of the distribution of rip-rap and retaining walls and other channel lining and armoring structures. The widespread distribution of revetments in a channel reach indicates historic and on-going instability problems. In addition, construction of revetments and hard channel lining can induce further downstream channel instability, as flows are deflected off of hard structures and problems are moved downstream.

- **Pool/Riffle Ratio**, as determined during the biological field inventories, using standard CDFG inventory procedures.

- **Exotic Vegetation**, or areas invaded by aggressive weedy non-native species.

- **Riparian Canopy**, including cover and species richness considerations.

A connotative letter was used on the summary maps to identify the nature of the major problem(s) in each reach (e.g. **B**=bank erosion, **F**=flooding, **S**=sedimentation, etc.). A number has also been assigned to each reach to reflect the severity of the problem, with **1**= minor problem, **2**= moderate problem, and **3**=major or significant problem. Criteria used to make the ratings are presented on the legend to the map. As an example, **B3** means that significant, widespread bank erosion problems occur within that reach. A summary of management problems by stream reach is provided in **Table 3-1.**

3.4 Waterway Problems and Needs

3.4.1 Flooding Problems

Background. There is a long history of flooding in the SLO Creek Watershed. Damaging floods have occurred in 1868-62, 1884, 1897, 1911, 1948, 1952, 1962, 1969, 1973, 1995, and 1998. Even so, relatively few structural flood control projects were implemented. The only major flood control project recently constructed within the San Luis Obispo watershed study area is located above the Los Osos Valley Road bridge, where in 1978, as part of the Tract 592 subdivision east of SLO Creek, a private developer channelized San Luis Obispo

Creek to protect future development from the 100-year flood (MDW Associates, 1982) and for the reference list from Phase I report. The channelization consisted of excavating one of the channel banks (alternating east and west) to form an in-channel floodway terrace, leaving the existing channel bottom in its natural state and planting the newly formed banks. The floodway terrace has not been managed since construction and has accumulated several feet of sediment. It is vegetated with dense, shrubby willows. This has reduced the channel conveyance capacity in this reach from the 100-year design to approximately 50-75 years.

The most recent damaging floods occurred during January and March 1995, with a lesser flooding problem in 1998. Within San Luis Obispo, flow overtopped streambanks near the intersection of Marsh and Higuera Streets and remained out of the channel for nearly three miles downstream, with damage estimated at nearly $2.3 million (ACOE, 2000). The City and Zone 9 also spent approximately $1 million to repair bank erosion caused during the winter of 1995. Damage occurred near the town of Avila during both the January and March 1995 events, where high flow and debris blockages caused extensive damage to several bridges across the creek.

Historically, the 1969 and 1973 events were more damaging than the 1995 floods, in present day dollars. According to ACOE estimates (in year 2000 dollars), the 1969 storm caused approximately $6.92 million damage within the SLO Creek watershed, and the 1973 storm caused $13.6 million (of which $899,000 occurred along Stenner Creek, $161,000 along Brizziolari Creek, $3.6 million along Prefumo Creek, and $241,000 along See Canyon Creek).

According to George S. Nolte and Associates 1977 *Flood Control and Drainage Master Plan for the San Luis Obispo Creek Watershed*, during the 1973 event, San Luis Obispo Creek spilled out of its banks downstream of Osos and Marsh Streets, flooding the downtown business district. Flood damage near the intersection of Marsh and Higuera Streets was extensive (as it was during the 1995 event). Floodwaters spilled across Highway 101 near the Madonna Inn, causing flooding four feet deep in places. Highway 101 overtopped near the confluence with Prefumo Creek, where flood depths as high as three feet were recorded. Along Stenner Creek, flow left the main channel above Foothill Boulevard and flowed overland through the area between Santa Rosa and Chorro Streets. Flooding in the Stenner Creek watershed was also caused by a constriction at the Highway 101 Bridge (which has since been replaced). The City has also replaced the Santa Rosa Street Bridge.

Table 3-1
Management Problems by Reach

Reach No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Reach Name	Avila Bay Rd- San Luis Bay Dr	San Luis Bay Dr – Ontario Rd	Ontario Road- San Luis Bay Dr	San Luis Bay Dr.- Farm Bridge	Farm Bridge- South Higuera on-ramp	S. Higuera onramp S. Higuera Bridge	South Higuera bridge LOVR	LOVR Prado Road	Prado Road – Madonna Road	Madonna Road – Marsh Street Bridge	Marsh Street bridge- California Street	California Street – Andrews Street	Cuesta park	Cuesta Grade	Upper E. Fork	Lower E. Fork	Upper Prefumo above Laguna Lake	Lower Prefumo below Laguna Lake	Lower Stenner below Chorro	Mid Stenner Chorro- Santa Rosa	Upper Stenner Santa	Stenner Cal Poly above Brizziolari	Brizziolari Creek	See Cy n Creek
F - Flooding	F3	F3+	F3+	F3+	F3+	F3+	F3	F2	F3	F3+	F2	F1+	F2	F2+	F1	F2	F2	F3+	F1	F1	F2+	F1+	F2-	F2
B-Bank Erosion	B3-	B1	B2	B1	B1	B3	B2	B2	B2+	B2	B2	B2	B1	B3	B2	B3	B2	B1	B3-	B1	B2	B3	B2	B2
R - Revetment	R1-	R1-	R1-	R1-	R1+	R1-	R2-	R2	R2+	R3	R3	R1-	R2	R1+	R1	R1	R2+	R1+	R1	R1	R1-	R1-	R1-	R1
I-Channel Incision	I0	I0	I0	I0	I0	I1+	I2+	I1-	I1+	I1	I2	I0	I2	I2+	I2	I2	I0	I3	I1	I0	I0	I0	I1-	I2
S - Sedimentation	S0	S1-	S1+	S1+	S1-	S1	S1+	S1+	S1	S2	S0	S0	S0	S0	S0	S0	S3	S0	S1	S0	S0	S0	S0	SO
O-Flow Obstruction	O1	O3	O3	O3	O2+	O1-	O1-	O2	O1	O1	O0	O0	O0	O3	O1	O1	O0	O1	O0	O0	O0	O1-	O2	O1
P – Pool/Riffle Ratio	P3	P2U/3L	P2	P1	P3	P3	P2	P2	P3	P3	P1-P2	P1	P2	P3	-	-	P2	P3	P3	P1	P2	P2	P2 est	-
E-Exotic Vegetation	E2	E3	E2U/3L	E3	E3	E3	E3	E3	E3	E3	E3	E2-E3	E2	E3	E1	E1	E2	E3	E3	E2	E2	E2	E2U/2L	E1
V-Native Riparian Vegetation	V1U/3/L8	V1 7	V2U/3L8	V2 6	V2 8	V2 8	V2U/3L7/8	V2 7	V3 9	V2U/3L8/9	V3 7/8	V1-V2 4/6	V2 6	V2U/V1L7/8	V3 4	V3 4	V2-V3 6/7	V2 8	V3 9	V2	V2	V1-V2	V1-2U/V2-3L	V1-V2

KEY: Flooding F3 = Flooding frequency < 25 years; F2 = 25-50 yrs; F1 = 50 + yrs.
Bank Erosion B3 = Several classes of extreme erosion, numerous critical sites, or very extensive minor to moderate erosion;
B2 = some significant or critical problems in reach, B1 = minor, no critical sites
Revetments R3 = large, barren, or failing > 25% of area, or small, stable revetments > 50%/ R2 = large, unstable 0.15-25%, or small/stable 25-50%.
R1 = large, barren, or failing 0.5 – 0.15%, or small/stable 10-25% of area.
Bed Incision I3 = Bed Incision > 1.4M; I2 = .8 – 1.4 M; I1 = 0.3 – 0.7M; I0 = < 0.3M (since 1974)
Sedimentation S3 = Sediment accumulation to 1.0M often widespread, S2 = 0.5 – 1.0 M, localized; S1 = < 0.5M thick, very localized,
Flow Obstruction O3 = willow thickets & LWD may be contributing to flooding/bank erosion, O2 = emerging problem; O1 = minor, but monitor problem development
Pool/Riffle Ratio P1 = Good; P2 = Fair; P3 = Poor
Exotic Vegetation Based on frequency and percent cover; E1 = Light; E2 = Moderate; E3 = Heavy.
Native Species Native Riparian Vegetation; V1 = Diverse and continuous; V2 = Diverse but not continuous or continuous but not diverse; V3 = Sparse, and/or lacks native diversity.

Note: U = Upper par of reach, L = lower part of reach – where indicated (i.e., V2U/2L).

The culverted section of SLO Creek beneath downtown San Luis Obispo, between Osos and Chorro Streets, was a particular problem during the 1973 storm. This structure, often termed the "under-city" culvert, has an estimated flow capacity according to (Nolte, 1977) of 127 cubic meters per second (4500 cfs), which is about a little more than a 15-year event according to the hydrologic analysis. This is less than the 25-year recurrence interval capacity reported by Nolte, based on ACOE studies. However, since flow during the 1995 storm, which was estimated to be between 140-150 cubic meters per second (4900-5300 cfs) through the under-city culvert, did not spill out of the channel at Osos Street, it appears that the under-city culvert may have additional capacity beyond what Nolte and Associates reported. According to the present hydrology numbers, the 1995 flood was approximately a 17-year event through Downtown, so it appears the channel has at least a 17-year capacity there. A detailed hydraulic study involving physical modeling would be necessary to improve the capacity estimate of the structure. In any case, structural improvements to the under-city culvert performed in 2000-2001 were not designed to improve the conveyance of the facility.

FEMA Floodplain Designation. The 1981 FEMA Flood Insurance Rate Map (FIRM) depicts a generally 300-400 meter (1000-1300 foot) band of flooding (100-year average recurrence interval) extending along SLO Creek, with narrower widths along Stenner and Prefumo Creeks. The extent of flood prone areas was verified by hydrologic/hydraulic studies completed as part of this WMP. However, the WMP Hydraulic/Hydrology studies (**Appendix C**) found the depth and frequency of flooding to be greater than in the FEMA studies. The 1995 flood caused significant damage to private property within the City and SLO Creek, especially the Mid-Higuera area, but provided some clearing and enlargement of the waterway. If this same flood occurred today, (2002) it would probably not produce the depth of flooding experienced in 1995. Conveyance capacity increased at many locations by down cutting and widening the channel through erosion and removal of flow inhibiting vegetation. However, in many areas the channel vegetation has recovered. At other locations the capacity has been reduced by sediment deposition (Marsh Street and Los Osos Valley Road Bridges), and at point bars on the inside of channel meanders. The most noticeable area of willow-hardened bars occurs in Reach 8 near and downstream of the City's Wastewater Treatment Plant below Prado Road.

Problem Identification. Flooding can occur (even during the 10 or 20-year recurrence internal flood flows) in some locations along SLO Creek, due to flow constrictions at bridges and other areas of limited channel conveyance. Denuded banks and erosion have added plant debris and sediment that re-deposited downstream. Undermined trees have toppled into the channel in some areas, or will, during the next large flood event. Vegetation can collect debris, reducing channel capacity and deflecting flows against banks. In many areas, the sediment bars that were deposited during the 1995 and 1998 high flows have now become overgrown with dense willow thickets, and have become more or less "hardened". These willow vegetated bars form significant channel obstructions, and can deflect flow against banks, causing bank erosion. Flood risk increases each year due to delayed channel management.

A set of rainfall-runoff and stream flow computer models that numerically describe the hydrologic and hydraulic performance of the watershed and stream system was developed as part of this WMP. The modeling results, along with existing reports of historic flood damage, provide a comprehensive picture of where flooding is likely to occur in the future. The hydrologic and hydraulic models provide information on flood channel conveyance capacity, flood reoccurrence intervals, and estimates on the extent of floodway. **Figure 3-2** summarizes the flooding problems that occur along SLO Creek and its principal tributaries.

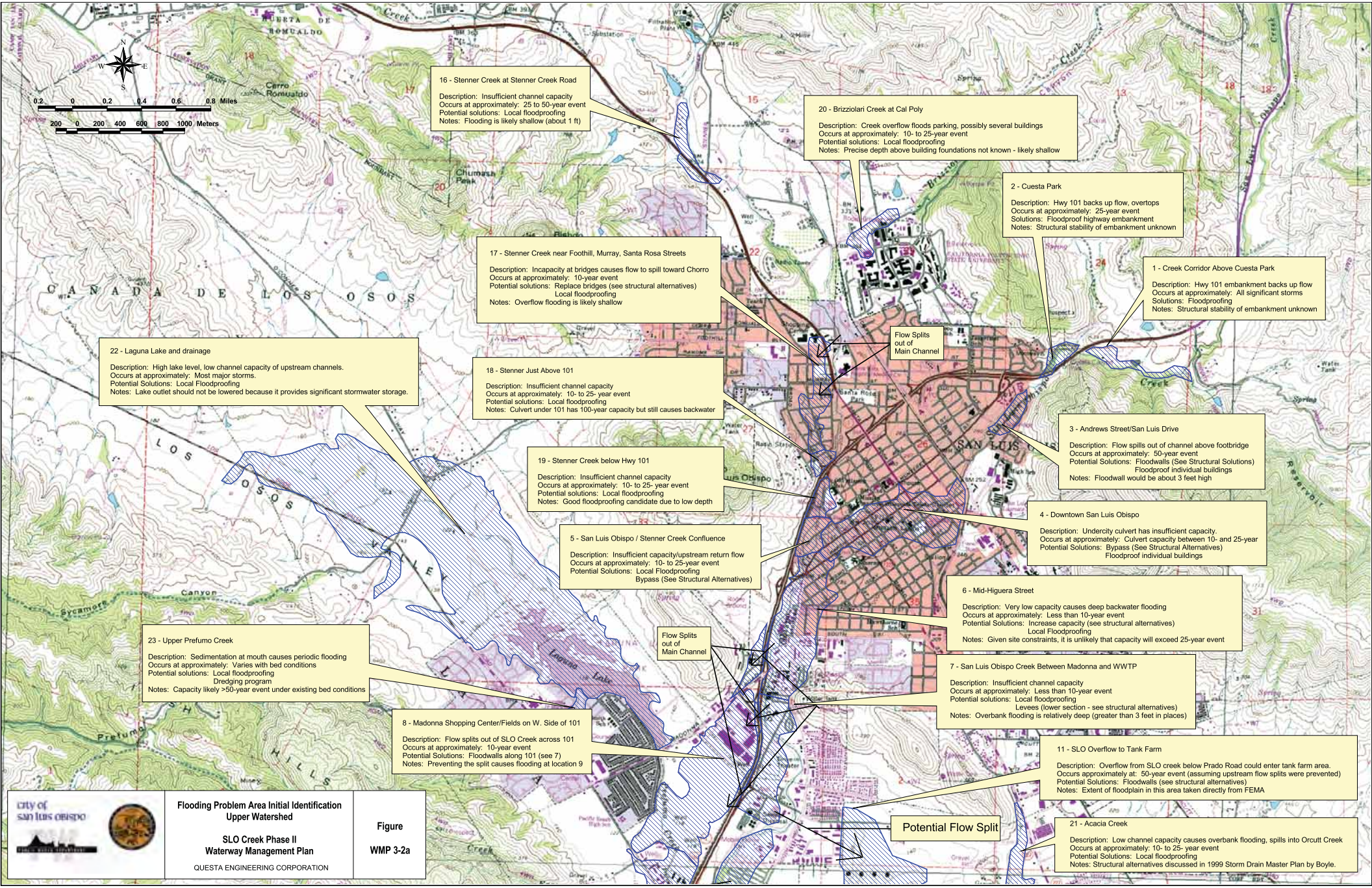
Management Needs. The feasibility of providing 100- year flood protection for developed properties along all of the major streams in the watershed is limited by the large amounts of runoff generated during storms. The terrain and hydrology of the watershed are conducive to frequent and widespread flash flooding along the major streams. The hydrologic analysis revealed that urbanization of the watershed has had only minor effects on larger flooding events; severe flooding was common even under pre-development conditions. To a certain extent flooding is inevitable and the most cost effective/best strategy may to avoid building on flood prone areas in the lower watershed, selectively purchase buildings subject to recurrent flooding, and fix only the generally localized areas where flooding occurs to reduce the frequency and depth of flooding and flood damage. Flood proofing of buildings in flood prone areas can also be an important strategy.

Management of willows at hardened bars (and other areas with dense, in-channel vegetation) is a critical maintenance need and management problem. Informed management of the flood-modified channel and banks affords an opportunity to reduce the impact of future floods. Because of system wide channel capacity constraints, perennial vegetation in the active, most efficient part of the channel should be maintained at a low level. Willows should be discouraged from re-colonizing point bars for more than two or three consecutive years. If the growth persists, there will be increased flow friction losses and sediment deposition. This will increase the depth of flooding, or cause lateral erosion, particularly at channel bends. In contrast, performing selective vegetation removal and replanting with desirable species (replacing undesirable exotic vegetation, plugging gaps in canopy cover, or planting areas denuded by the 1995 flood) will help stabilize the bank, direct deposition into toe protecting berms, and reduce the sediment supply of future floods. Detailed procedures for vegetation management are included in the ***SLO Creek Watershed Stream Maintenance and Management Program*** document prepared as a separate work product of these Phase II studies.

Even with vegetation management, structural channel modifications will be needed to reduce flood risk in a number of areas of the City. Flooding problems along SLO Creek and proposed flood management solutions for specific areas are discussed in **Section 6.**

3.4.2 Bank Erosion

Background. Stream bank erosion is a natural process. Causes of erosion and bank failure include hydraulic forces as well as geotechnical instabilities, and local flow deflection, such as off of downed trees or adjacent “hard” bank repair structures. Natural processes can be



city of san luis obispo

Flooding Problem Area Initial Identification
Upper Watershed

SLO Creek Phase II
Waterway Management Plan

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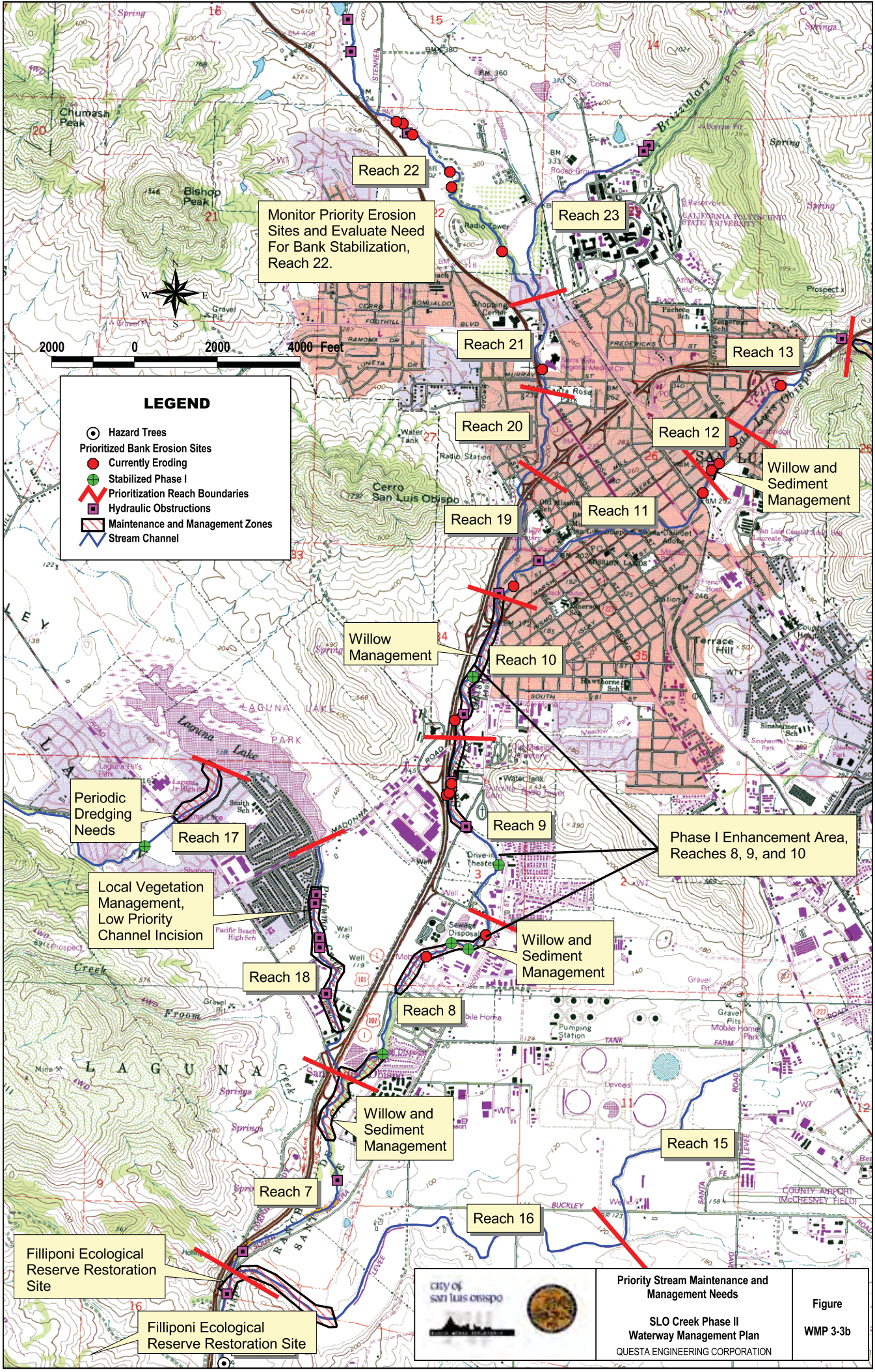
Figure

WMP 3-2a


Reach 22
Monitor Priority Erosion Sites and Evaluate Need For Bank Stabilization, Reach 22.
Reach 23
Reach 21
Reach 13
Reach 20
Reach 12
Willow and Sediment Management
Reach 19
Reach 11
Willow Management
Reach 10
Periodic Dredging Needs
Reach 17
Reach 9
Phase I Enhancement Area, Reaches 8, 9, and 10
Local Vegetation Management, Low Priority Channel Incision
Willow and Sediment Management
Reach 18
Reach 8
Willow and Sediment Management
Reach 15
Reach 7
Reach 16
Filliponi Ecological Reserve Restoration Site
Filliponi Ecological Reserve Restoration Site
2000 0 2000 4000 Feet
LEGEND
Hazard Trees
Prioritized Bank Erosion Sites
Currently Eroding
Stabilized Phase I
Prioritization Reach Boundaries
Hydraulic Obstructions
Maintenance and Management Zones
Stream Channel
Chumash Peak
Bishop Peak
Cerro San Luis Obispo
Laguna Lake
Terrace Hill
Prospect x
Brizzolari
Priority Stream Maintenance and Management Needs
SLO Creek Phase II Waterway Management Plan
QUESTA ENGINEERING CORPORATION
Figure
WMP 3-3b

accelerated by human intervention and land use changes, often at a watershed scale. SLO Creek bank conditions range from stable and well vegetated to near vertical eroding banks. All reaches of SLO Creek and its tributaries have some bank erosion problems, but widespread bank erosion is a significant problem upstream of Prado Road in Reach 8, and in the Cuesta grade area of Reach 14. Bank failure and significant bank erosion occurs throughout the study area. Bank protection has generally been the responsibility of the individual creekside landowner, except where channel modifications were implemented to protect public facilities.

Problem Identification. Accelerated bank erosion results from land uses that affect the stream corridor, including overgrazing, agriculture, roads and utility construction. The watershed reconnaissance completed as part of this WMP's geomorphic studies found that bank erosion is one of the biggest contributors to sediment load in the system, more than upland erosion. Bank protection is necessary when erosion:

- Causes or could cause significant damage to a property or adjacent property,
- Is a public safety concern,
- Negatively impacts recreational use,
- Negatively affects water quality, or
- Impacts riparian habitat.

Problem causes include toe erosion and bank undercutting; over-steepened vertical slopes too high for the natural soils to support do to channel bed incision, and natural downstream migration of meander bends. Many of the most significant failures occur due to slow bend migration. Bank protection has been used previously along SLO Creek to control erosion and provide bank stability, including rock rip-rap or gabion baskets. This can reduce creek shading and displace desirable riparian vegetation. Some previously installed revetments are now failing, with undermined foundations, due to channel incision. Banks are often high, ranging from three to seven meters.

Management Needs include repairing stream banks that are actively eroding and providing erosion protection at critical sites. Repairs may take several forms from installing hard structures (e.g., rock, concrete, sack concrete, gabions) to soft structures (e.g., erosion blankets, willow wattles, willow brush mattresses, log crib walls, pole plantings, etc.). Vegetative and biotechnical methods will be the preferred method of bank repair and protection, consistent with an engineering analysis of hydraulic, geotechnical and geomorphic constraints. Hard structural approaches will be used sparingly, and only at highly constrained sites.

Before new bank stabilization measures are applied to an eroding bank section, it is important to understand the cause of the problems, characteristics of the channel and bank, and the mechanisms of failure. Stabilization designs that are implemented without this analysis could transfer the problem to the other side of the channel, upstream or downstream, or result in failure and/or costly maintenance.

Since many areas of failing banks occur on private property along the creek banks, the bank erosion program is focused on providing design guidelines for use in developing acceptable repair plans, and an efficient regulatory permitting program. These are contained in the ***SLO Creek Watershed Drainage Design Manual***; a separate work product prepared as part of the Phase II studies.

3.4.3 Channel Bed Erosion

Background. Channel incision occurs in Reach 14, above Cuesta Park, along lower Prefumo Creek, and Reaches 5, 6, 7, 8, and 9 between Madonna and below South Higuera Road. Historically, channel incision has occurred upstream of these reaches, through much of the downtown area, but the rate of incision appears to have slowed in this area. The channel incision of SLO Creek in Reaches 5 and 6 have caused secondary erosion of creek tributary channels such as East Fork Creek and Davenport Creek, where headcuts are working their way upstream. These may require the installation of small grade control structures, or bank erosion of tributaries will worsen.

Problem Identification. Channel incision can pose significant hazards, particularly to rigid structures (retaining walls, bridges) when toe support is removed. Over-steepened, unprotected earthen banks affected by channel bed erosion can also fail. Channel incision de-waters stream side alluvial aquifers, affecting riparian communities and wetlands. In some areas summer base flows and channel hydraulic capacity may be increased as the channel cross-sectional area is enlarged through deepening.

Management Needs**.** One approach is to install series of small grade control structures, such as check dams, or boulder clusters, to slow velocities, flatten grades, and stabilize the bed. However, poorly designed structures trap sediment, deflect flows, and are potential barriers to fish passage. Therefore, use and placement of grade control structures must be well designed. Grade control structures consisting of boulder or rock weirs, extending no more than 0.3 meter (1 foot) above the channel invert, can stabilize the bed, allow fish passage, and introduce stream bottom diversity by providing pools and hiding habitat. Recommended grade control structures are in **Section 5.**

3.4.4 Vegetation And Woody Debris Management

Background. Dense vegetation can adversely affect the ability of the channel to contain the volume and velocity of floodwaters necessary to prevent flooding. Vegetation management may also be needed to meet local fire codes requiring the control of combustible weeds and grasses; to provide visual clearance for inspection of structures; and to provide maintenance road access. Vegetation management includes plant removal, thinning and limbing-up, pruning, weeding, and clearing. In the San Luis Obispo Creek Watershed, an important element of vegetation management is the control of aggressive weedy exotics, such as Giant Reed (Arundo donox). The City, Zone 9 and the Land Conservancy of San Luis Obispo have had an active Arundo donax eradication program for over 6 years.

A common but localized maintenance problem is woody debris caused by large trees falling into waterways. This includes large eucalyptus or cypress trees on slopes that have been undermined (by channel incision or toe erosion). Streamside landowners and maintenance staff have been concerned about the tendency of these large trees to divert flow against the bank, increasing the potential for erosion and bank failure. Fisheries biologists once considered log jams to be obstacles to fish passage, but recent research has shown that these are not normally barriers to movement.

Problem Identification. Vegetation management needs are widespread throughout SLO Creek. Some of the more critical areas include the channel section opposite the City's Wastewater Treatment Plant, upstream of the Prado Road Bridge, and throughout the Mid-Higuera area below the Marsh Street Bridge. Vegetation management is necessary to maximize capacity, and reduce the frequency of flooding from low recurrence interval storms. Dense shrubby streamside vegetation, often with lower terrestrial habitat value, is becoming rapidly reestablished. Vegetation management to selectively convert shrubby growth to a higher value, more hydraulically efficient mixed species riparian forest is a long-term management goal, although management must also recognize the need to retain important clusters of willows and other overhanging vegetation over important summer pools.

Downed trees are a part of the natural system. They provide structure, forming pools as well as providing habitat and cover to a number of aquatic organisms.

Management Needs. The **Stream Maintenance and Management Program** (SMMP) provides guidelines and techniques for how to manage woody vegetation along SLO Creek and its tributaries. Frequency of vegetation management varies from annually to 3-5 years. A gradual, phased approach may be used to convert shrubby willow vegetation, or areas of large Eucalyptus or other exotic trees, into a more hydraulically efficient stand of native sycamores, tree willows, oaks, or cottonwoods. This involves thinning and removing willow stands and exotics, pruning to thin and remove lower limbs of larger, more desirable forms of individual willows, and replanting with natives, such as sycamore, cottonwoods, and alders. This may take up to ten years to achieve, but habitat values would be improved, and maintenance costs reduced, as the larger trees eventually shade-out the understory. Native vegetation will also be planted as part of mitigation and habitat enhancement projects. Initially, it is important to control weeds and irrigate at revegetation sites to increase the survival and establishment of native species.

Vegetation management is also important to control invasive, non-native species. Exotics can spread into areas where they affect channel capacity and compete with native plant populations. In the SLO Creek watershed, this may include selective thinning and removal of Eucalyptus trees, as well as areas of dense castor bean, cape ivy and giant reed (*Arundo donax*). Timing of exotic removal must also consider nesting activities of raptors and other wildlife.

3.4.5 Sediment Management

Background. Sediment deposition is generally a natural process. It occurs where stream velocity slows and the channel gradient flattens out in the valley floor. This occurs at Marsh Street Bridge, near the City's Wastewater Treatment Plant (due to the previous downstream channel widening), upstream of the Los Osos Valley Road Bridge, and the arm of Prefumo Creek entering Laguna Lake below Los Osos Valley Road. In developed areas, sediment deposition affects flood control capacities, especially where modified channels were not designed to be self-maintaining.

Over time, development has encroached upon the flood plains. Most creeks that once flowed over a wider, meandering area that fluctuated in response to environmental conditions are now confined to narrow channels with homes and businesses built near the edge of the stream bank. Sediment is deposited as the stream attempts to recreate a meandering low flow within the modified and constrained channel. Sediment accumulation problems occur both locally and throughout a particular reach.

Problem Identification. Sediment accumulation reduces channel hydraulic capacity, which can lead to flood channel break-out points, backwater effects, or with point bars, can deflect flows against banks, causing erosion.

Management Needs**.** Mechanical removal of sediment deposited within a stream is needed to restore the flood capacity of existing streams, and to restore habitat values. Typically, sediment is removed when it 1) reduces capacity, 2) prevents structures such as outfalls, culverts and bridges from functioning as intended, 3) impedes fish passage and access to fish ladders, and 4) causes water quality problems.

In addition to sediment removal, source control through repair of eroding gullies will also be important to waterway management. This is addressed in Section 4.3, Watershed Management Frame Work.

3.4.6 Hydraulic Structures and Revetments

Background**.** Hydraulic structures consist of culverts, storm drain outfalls, weirs, dams, grade control structures, revetments and retaining walls (such as gabions and rock rip-rap or walls). These structures, including their size and condition were included in the Phase II inventory of existing creek conditions (**Appendix A**). In some reaches of upper SLO and Stenner Creek, there are extensive areas of hard structures.

Problem Identification. Many older structures were not well designed or constructed. Some structures have footings undermined by channel bed incision, or are in danger of toppling over, especially in Reaches 9 & 10 extending through the main part of the City. In other cases, the revetments encroach into the channel and act as flow obstructions, or deflect flow against unprotected banks. Many storm drain outfalls do not have energy dissipaters.

Management Needs**.** Some existing hydraulic structures can be replaced using designs that incorporate habitat elements, and reduce geomorphic impacts to the creek channel. However, many existing channel revetments were constructed privately to protect private property. City/Zone 9 can institute a program to inspect, repair and replace structures in failing condition and retrofit public hydraulic structures to include habitat elements. However, there is limited opportunity to retrofit private structures with more environmentally friendly designs. City/Zone 9 can require use of biotechnical designs when failing structures are replaced. Bank protection is not appropriate at all locations. Design guidelines for bank repair; including the use of biotechnical methods is included in the **Drainage Design Manual**, prepared as a Phase II work product.

3.4.7 Flood Channel Constrictions

Background. Channel constrictions are bottlenecks or channel segments that lack adequate cross-sectional area for flood conveyance. Channel constrictions can occur naturally, for instance, where bedrock exposure in the channel bank limits the width of a channel, from channel cross section conveyance restrictions, such as bridges, from natural occurrences, such as downed trees or shrubby channel growth, or from man-made obstructions, such as rip-rap or concrete-wall sections that encroach into the channel. Areas of channel constrictions due to dense willow growth occur in the Mid-Higuera area, from the Marsh Street Bridge to downstream of Madonna Road, (Reaches 9 & 10). Constrictions from built revetment obstructions in the channel occur in the downtown and Mission Plaza area, and upstream to the Santa Rosa Bridge, as well as lower Stenner Creek (Reaches 11 & 12).

Problem Identification. The most common form of channel constriction along SLO Creek is the haphazard placement of inappropriate channel protection structures (broken concrete, rock, etc.) on the channel banks and encroachment into the creek. In areas with flooding problems, these structures reduce the hydraulic capacity of the channel. Many of these private-party attempts at channel protection are old (prior to 1982) and are in danger of failing, especially in Reaches 9&10. The channel hydraulic analysis also indicated a number of bridges that present restrictions to flood flow during large events, including the Murray Street and Foothill Ave. Bridges.

Management Needs. Replacement of bridges that lack flood conveyance capacity should be considered a high priority. Bank protection structures that are hydraulically efficient, and do not cause water surface elevations to rise (due to channel constriction) can be designed and installed. A pro-active program to remove or retrofit obstructive revetments is also needed. Routine vegetation management in constricted sections is a critical management need. **Section 6** discusses structural measures to increase flood conveyance capacity by widening channel constrictions, along with the recommended program of bridge replacement.

3.5 Sensitivities, Constraints, and Opportunities

The resource inventory and hydrologic analysis provided the basis for exploring opportunities to achieve multiple benefits by managing resources in an integrated fashion. The analysis focused

on opportunities for enhancing or restoring riparian and aquatic habitat, decreasing flooding problems, and stabilizing failing channel banks.

There is significantly less high quality riparian habitat along the major creeks and streams in the watershed than under pre-development conditions, and wildlife populations that depend on these habitats are declining. The corridor is narrow, invaded by aggressive exotics, and fragmented, and in many places there are not good connections with other important natural upland habitat areas.

Constraints to achieving habitat enhancement, flood hazard reduction, and bank stabilization have also been identified. Although opportunities for creating and enhancing habitat are abundant along the major creeks in the watershed, they require cooperation by interested landowners for successful project implementation. Most of the bank repair projects will be costly to implement. **Figure 3-3** summarizes the priority stream management and maintenance needs, including opportunities for stream restoration and enhancement.

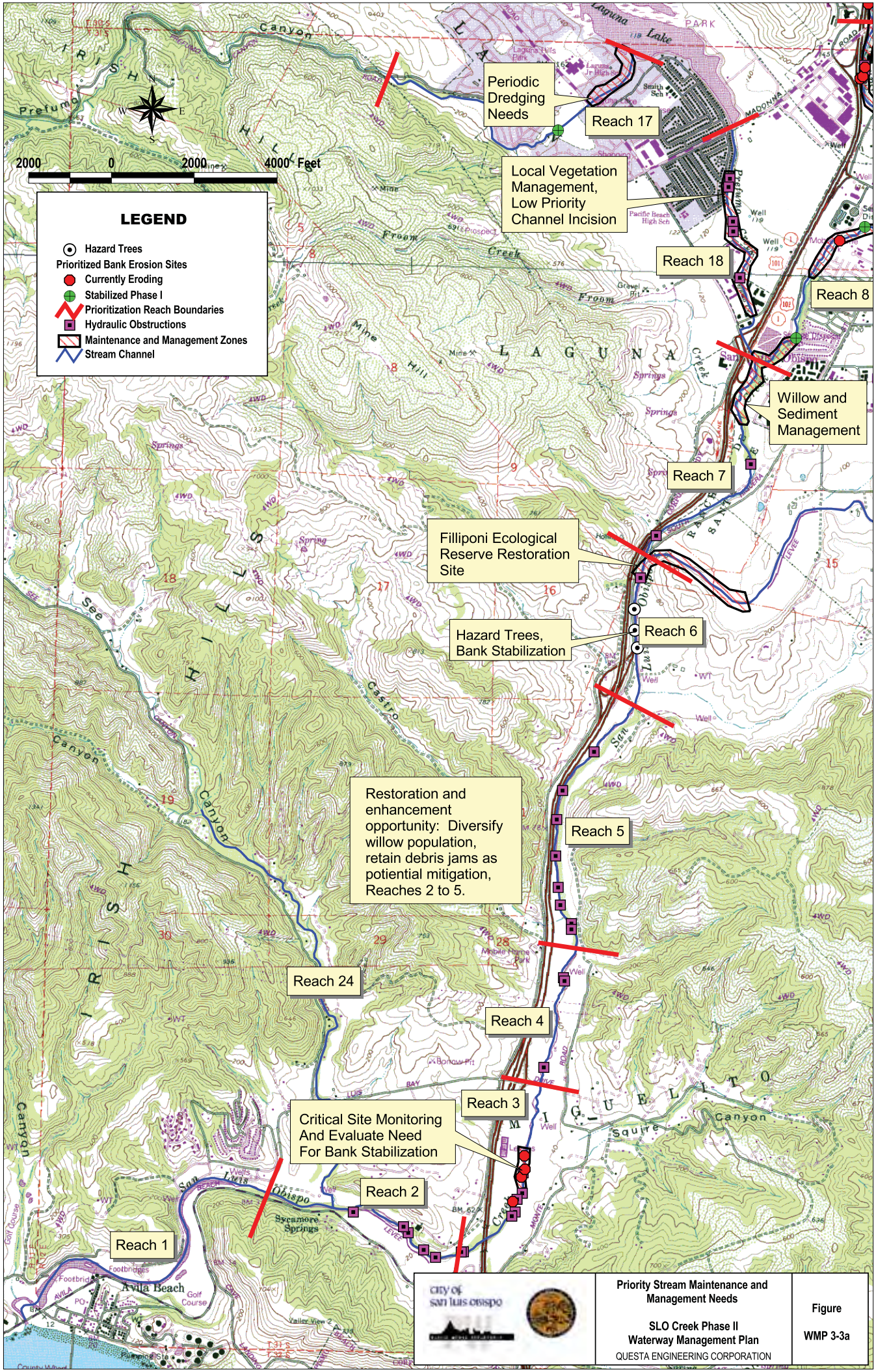
3.5.1 Sensitivities

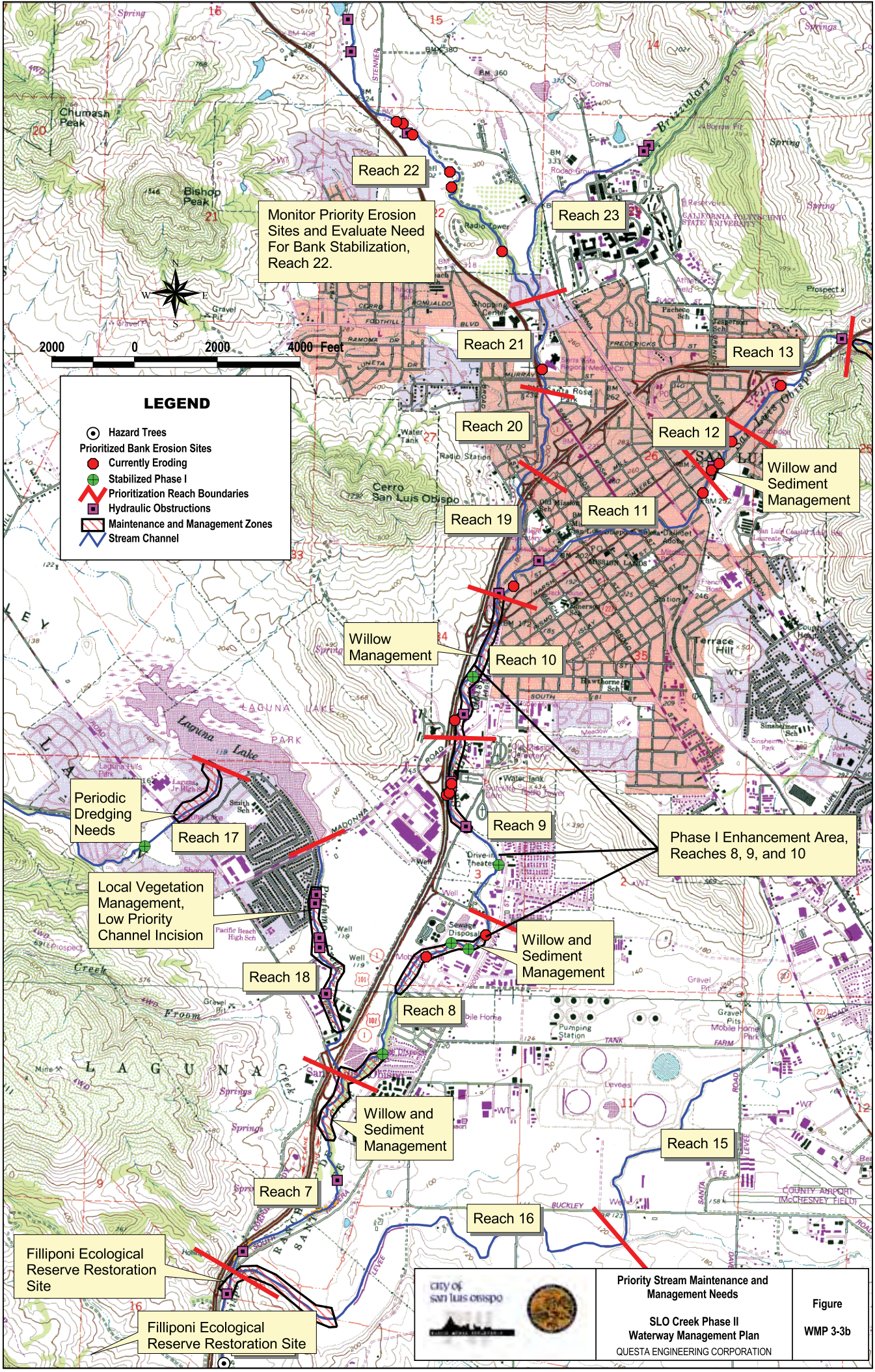
Sensitive features that exist within the study area are the remnants of mature, mixed riparian forest, existing in small isolated to moderately sized patches, scattered throughout the study reaches and the few remaining pools and riffles. These areas represent a fraction of the natural landscape, but are still valuable even as fragmented habitat for many species of birds, small mammals and anadromous fish, including the Federally protected Red-legged frog and southern steelhead. The most significant stands of riparian forest exists within the lower portions of Reach 14, below the confluence of Reservoir Canyon Creek, along the east bank are those that include both mature coast live oak, California bay, sycamore, cottonwood, walnut and large willows. Scattered throughout the study reaches along creek banks and terraces exist smaller stands of endemic tree species or individuals of significance. Planning, design, and construction must be particularly sensitive to the local occurrence of these resources.

3.5.2 Constraints

Creek reaches within the study area have potential for restoration and enhancement, as well as significant constraints. The main constraints to any significant restoration or enhancement within the study area include: (1) the lack of undeveloped riverbank property along much of the study reach; and, (2) the need to acquire or use substantial private land to achieve a continuous riparian corridor. With the exception of Reach 14 and some sections of Reach 8 and Prefumo Creek reach, a significant portion of the stream banks and adjacent upland areas have been severely encroached upon by development and land use, resulting in a narrow riparian corridor within which the extent of natural vegetation has been severely reduced, limiting potential enhancement opportunities.

The majority of the study areas lack sufficient area to restore the riparian corridor to its original historic condition. Present and future land use, existing urban encroachment and disinterested property owners preclude the restoration of a sustainable natural riparian


Periodic Dredging Needs
Reach 17
Local Vegetation Management, Low Priority Channel Incision
Reach 18
Reach 8
Willow and Sediment Management
Reach 7
Filliponi Ecological Reserve Restoration Site
Hazard Trees, Bank Stabilization
Reach 6
Restoration and enhancement opportunity: Diversify willow population, retain debris jams as potiential mitigation, Reaches 2 to 5.
Reach 5
Reach 24
Reach 4
Reach 3
Critical Site Monitoring And Evaluate Need For Bank Stabilization
Reach 2
Reach 1
2000 0 2000 4000 Feet
LEGEND
Hazard Trees
Prioritized Bank Erosion Sites
Currently Eroding
Stabilized Phase I
Prioritization Reach Boundaries
Hydraulic Obstructions
Maintenance and Management Zones
Stream Channel
Priority Stream Maintenance and Management Needs
SLO Creek Phase II Waterway Management Plan
QUESTA ENGINEERING CORPORATION
Figure
WMP 3-3a


Reach 22
Monitor Priority Erosion Sites and Evaluate Need For Bank Stabilization, Reach 22.
Reach 23
Reach 21
Reach 13
Reach 20
Reach 12
Willow and Sediment Management
Reach 19
Reach 11
Willow Management
Reach 10
Periodic Dredging Needs
Reach 17
Reach 9
Phase I Enhancement Area, Reaches 8, 9, and 10
Local Vegetation Management, Low Priority Channel Incision
Willow and Sediment Management
Reach 18
Reach 8
Willow and Sediment Management
Reach 15
Reach 7
Reach 16
Filliponi Ecological Reserve Restoration Site
Filliponi Ecological Reserve Restoration Site
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LEGEND
Hazard Trees
Prioritized Bank Erosion Sites
Currently Eroding
Stabilized Phase I
Prioritization Reach Boundaries
Hydraulic Obstructions
Maintenance and Management Zones
Stream Channel
Chumash Peak
Bishop Peak
Cerro San Luis Obispo
Laguna Lake
Terrace Hill
Prospect x
Brizzolari
Priority Stream Maintenance and Management Needs
SLO Creek Phase II Waterway Management Plan
QUESTA ENGINEERING CORPORATION
Figure
WMP 3-3b

system with a diverse community of natural plants and animals. Restoration and enhancement should focus on the creation and maintenance of a system that supports and maintains native components of vegetation, wildlife and fisheries, provides for reduced erosion, flood risk, increased stream bank stability and is compatible with surrounding land use. Other constraints include: areas with active erosion, low cover values and low species diversity; exotic plant species; areas dominated by thickets of willows; areas dominated by exotic tree species; exotic understory areas; and areas low in cover values due to site disturbance.

3.5.3 Restoration and Enhancement Opportunities

Excellent opportunities exist to enhance, restore and preserve some of the remaining mixed riparian forest and scrub. These remnants of the natural landscape should be preserved whenever possible, and potentially provide the starting basis for a much more extensive riparian greenbelt or other stream-related easement. However, while it is important to preserve and maintain areas of existing quality habitat, numerous other opportunities exist for the restoration and enhancement of degraded habitat. Determination of these opportunities is a result of the inventory and examination of several features including actively eroding areas, low vegetation cover, presence and abundance of invasive exotic species and low native species diversity.

Preferably, to improve habitat value, exotic vegetation should be removed and replaced with native species. Replacement planting can be phased to allow continued shading. Priority should be given to enhancing habitat values in stream segments, which have some existing quality habitat in the vicinity or area of work, or in immediately adjoining reaches.

Continuity of quality habitat is important for aquatic life and most terrestrial species. Many species have a minimum habitat size or area requirement, require a diversity of plants for seasonally available food and cover, or require safe travel lanes or movement corridors between habitat patches and differing kinds of habitat, particularly watercourses. Protecting and enhancing existing valuable habitat or the fringe of such habitat generally has a better potential for success than enhancement of isolated pockets of habitat that result in a habitat fragmentation pattern.

Enlargement of an existing corridor of riparian vegetation is often a valuable habitat enhancement measure, along with inclusion of a buffer strip of limited permissible uses, separating urban uses from the corridor. In addition, habitat values are generally enhanced when channel beds and banks are earthen, rather than concrete or rip-rap. Where hydraulic conditions allow, an unarmored channel design should be given first priority.

Continuous, diverse riparian corridors are important for most species of mammals, reptiles, and amphibians. The lack of continuous or connected habitats is not as important for birds since they can fly to isolated patches of habitat. The existing fragmentation of numerous types of habitat prevents significant movement of species along this corridor. One goal of enhancement is to preserve and maintain areas that can provide this continuous corridor.

4. WATERSHED MANAGEMENT FRAMEWORK

A well-managed watershed is needed for a healthy stream ecosystem. The condition of the watershed directly affects a number of important stream functions, including summer low flow or base flow, peak flows and flood flows, channel bank stability and channel bed conditions, and water quality. Upland erosion of farmland and grazing land is a significant component of a watershed management plan, as is fire management and damage repair following wildfire in steep brushy and wooded watersheds, such as upper SLO Creek. In addition, watershed management and land use along the immediate stream corridor can also affect the streamside riparian zone that provides important shading and food resources to the creek system. Severe bank erosion can result in the loss of the riparian corridor.

Important upland habitat areas should be connected to the creek zones in some areas to allow movement of wildlife species between habitat types, and the creek riparian zones should not be fragmented, which prevents some species from moving safely under vegetative cover along the creek zone.

Although preparation of a detailed watershed management plan is not a part of the Phase II scope of work, some guidance and an overall framework is provided in this section, based on the results of the resource inventories and hydrologic studies.

A framework consisting of general management **Goals**, which respond to the identified management needs, problems and opportunities, as well as a list of recommended **Action Items** is provided. This framework can be used in future watershed planning efforts to focus on problem and priority areas, and to provide direction on important issues to resolve. A Watershed Enhancement Plan was recently prepared for the SLO creek watershed by the SLO Land Conservancy (2002), under a grant from the State Coastal Conservancy. Together these documents can direct future management efforts in this watershed.

The Zone 9 Advisory Committee developed eight Watershed Management Goals and recommended Action Items addressing the following issues:

1. Flooding
2. Erosion
3. Water Quality
4. Biological Resources
5. Land Use
6. Societal Values
7. Public Involvement & Education
8. Inter-agency Coordination

4.1 Flooding

Goal. Minimize and manage damages caused by recurrent flooding by utilizing both structural and non-structural flood management approaches in an integrated and cost effective manor, while also providing for the protection, restoration, and enhancement of the biological resources of the creek corridors.

Action Items

- Develop a comprehensive flood management plan that includes new floodplain management regulations and design standards, explores purchase of flood prone properties, and includes structural fixes to constricted channel sections that lack conveyance capacity.

- Develop an implementation plan, that includes a prioritization and implementation schedule, and identifies funding sources, including grant funding opportunities, existing government programs, and local revenues sources such formation of a drainage utility, imposition of drainage impact fees on new developments, and/or formation of a benefit assessment district covering flood prone properties.

Section 6 discusses these action items, included in the Phase II work program.

4.2 Erosion

Goal. Repair damages from upland watershed erosion and creek bank erosion at high priority locations; reduce the magnitude and severity of future erosion problems in the watershed.

Action Items

- Develop and implement a plan in coordination with watershed stakeholders to stabilize creek bank erosion in the priority locations identified in the resource inventory.

  Many of the bank erosion problems occur on private lands in the watershed, and/or on lands controlled by Caltrans under a Channel Change Easement (maintenance easement). Thus, it will be necessary to coordinate any design and construction work with Caltrans, a local non-profit, such as the Land Conservancy, or for farmlands, with the Coastal San Luis Resource Conservation District. This may be an expensive task, and will require grant funds and a long period to implement. The initial focus should be on the stabilizing high value habitat in the upper watershed in the Cuesta Pass area.

- Develop and implement a plan to stabilize the eroding railroad cuts in the upper SLO watershed, including repair of hanging and unprotected culverts.

- One of the most significant sediment sources in the SLO watershed emanates from historic railroad cuts and drainage crossings of the railroad, especially in the Cuesta

Pass. Since this historic construction activity predates most County ordinances regarding erosion and sedimentation, it will be necessary to work with the railroad authority in a cooperative fashion to plan and implement any remedial work. This activity can potentially be coordinated with the Regional Board's TMDL planning process.

- Develop and implement a plan to stabilize abandoned or seldom used dirt utility access roads and firebreak roads in upper Stenner and SLO Creek watersheds.

- Working with the Coastal San Luis Resource Conservation District and Cal Poly, and in cooperation with the Farm Bureau and other interest groups, develop and implement a program to address upland erosion on farm and ranch lands. The initial focus should be on the upper Prefumo Creek watershed.

  The watershed reconnaissance identified eroding dirt access roads to utility lines, and fire break roads as a potentially significant source of sediments in the upper Stenner and SLO Creek watersheds. Work could include installation of water bars and road drainage, reconstruction of culverted crossings, and removing old roads. The Mendocino County RCD has a useful publication on design and maintenance of dirt ranch roads that can be used for guidance.

- Integrate fire fuels management into the Watershed Management Plan. As evidenced by the Highway 41 fire that occurred in the upper Stenner Creek watershed in 1995, wildland brush fires can have devastating impacts on a watershed, increasing runoff , causing severe erosion and gullying of upland streams, and delivering large quantities of sediment to the creek system, causing bank erosion and other secondary problems. In the SLO watershed, the California Department of Forestry is responsible for fire management on private lands, while the US Forest Service, Los Padres National Forest is responsible for fire management on the public forest and range lands that occur in the Cuesta Pass area.

  Currently the fire management programs of the CDF and USFS are not integrated into other watershed management planning activities, and the importance and prioritization of fire management as an element of watershed management is not well understood or appreciated. Representatives from CDF and the USFS should be invited to attend the Zone 9 meetings, (and the CRMP, if established) to contribute their knowledge and expertise to this important aspect of watershed management.

4.3 Water Quality

Goal. Ensure that the waters of the SLO Creek watershed are of sufficient quality and quantity to sustain native riparian and aquatic habitat for both fish and wildlife populations, and human recreational activities.

Action Items

Many of the recommendations in this section are currently in place and being conducted by the City, County, SLO Land Conservancy, or Central Coast Salmon Enhancement.

- Continue to work with the Central Coast Regional Water Quality Control Board in NPDES Phase II Stormwater and TMDL planning and implementation efforts

- As part of Phase II NPDES and TMDL planning, educate watershed stakeholders and increase communication about pollution prevention by convening meetings among rural landowners, residential property owners and business operators to discuss methods and techniques for water quality management. Provide information on Best Management Practices at these meetings.

- Continue to support and coordinate volunteer stream monitoring programs in the watershed.

- Continue to support and coordinate creek awareness and creek cleanup days in the watershed.

- Coordinate with the Regional Water Quality Control Board to investigate and stabilize, as needed the abandoned mines, mine addits, and waste piles in the watershed.

  The significance of the abandoned mine addits on water quality is not fully known. This work can also be coordinated with the Regional Board's TMDL planning program.

4.4 Biological Resources

Goal. Protect, enhance, and restore the natural integrity of waterways of the SLO Creek watershed and their associated riparian and aquatic habitat.

Action Items

- Continue to provide support to ongoing programs for exotic species eradication and the restoration of riparian communities through creek planting and stream habitat enhancement programs.

- Support programs to identify barriers to fish passage and develop programs to remove or mitigate barriers.

- Cooperate with non-profit groups in programs to identify, acquire, enhance and restore sensitive and critical habitat areas along the creek corridor.

- The City and Zone 9 in cooperation with the Land Conservancy, Central Coast Salmon Enhancement, and California Conservation Corps currently have active programs in

each of the above 3 areas, some of which are supported by funds from settlement of the Unocal Oil Spill, (Avila Beach, 1992).

- Work with the Coastal San Luis Resource Conservation District and/or Land Conservancy to develop and implement a stream fencing, buffer strip, and creek planting program where appropriate, in rural and agricultural areas of the watershed.

- Explore the feasibility of selectively acquiring existing Caltrans right-of-way and/or channel management responsibility within the SLO Creek Corridor for proactive management and enhancement.

  Caltrans maintains a sizeable maintenance easement (termed a Channel Change Easement) along portions of the creek corridor and tributary drainages of SLO Creek from approximately the South Higuera Bridge to the San Luis Bay Drive overcrossing of the Creek. Apparently much of the stream corridor right of way or easements were acquired in the late 1940's and early 1950's when the former State Highway Department constructed the current alignment of Highway 101. This necessitated straightening and moving sections of the creek along portions of the highway.

  The straightening and realignment destabilized the creek in some areas, and the channel has responded by deepening and in places meandering to regain its once flatter channel slope. Serious bank erosion and bed instability problems occur in some of these areas.

  The Channel Change Easement that exists over much of this reach entitles Caltrans to conduct management or maintenance within the creek for the benefit of the adjacent highway, but specifically does not obligate Caltrans to perform channel maintenance.

  The primary mission of Caltrans is the maintenance and construction of the state highway and road system, not stream management. The County should explore with Caltrans the possibility of acquiring selective portions of the Caltrans right of way along the creek corridor, or assuming authority for creek management within the Channel Change Easement, for better management and enhancement. The legal issues associated with such a transfer would need to be explored. Such an acquisition or transfer of channel management authority should not be taken lightly as the County would be accepting responsibility for any liability, as well as for the costs of design, construction, monitoring, and ongoing management and maintenance of these stream reaches. This section of the creek has serious management needs as well as significant restoration and enhancement opportunities.

4.5 Land Use

Goals. Ensure that the political jurisdictions of the San Luis Obispo watershed implement or update land use policies and ordinances which provide responsible stewardship of the watershed's natural resources, protect people and property from flood damage, reduce erosion and stabilize banks, and prevent pollution.

Action Item

- Provide technical consultation to the City Community Development Department and the County Planning Department on the review and update of policies and ordinances that provide for protection and restoration of creeks during the next General Plan updates, including policies dealing with creek setbacks, buffer zones, and floodplain regulations.

- Develop a Public Promotion and Public Awareness Program in coordination with the City and County Floodplain Manager official to make the public aware of the need to protect open space areas within floodplains because of the hydrologic function they serve in storing floodwaters and filtering pollutant materials in flood flows.

4.6 Societal Values

Goal. Facilitate creation of public policies, ordinances, and planning and administrative mechanisms to discourage inappropriate and illegal uses of the creek corridors of SLO Creek and its tributaries.

Action Items

- Support and work with law enforcement agents and property owners to disband illegal encampments along the creeks.

- Utilize public works staff and contract agencies such as the California Conservation Corps to remove debris from the creek corridor.

- Support and work with City, County, and private social services providers to improve resources and services for displaced and homeless individuals outside of creek corridors

4.7 Public Involvement and Education

Goals. Broaden the public (and especially) creek property owner awareness and appreciation for the values of the waterway system and those of a healthy, diverse watershed

Educate the public, (especially students and future stakeholders), business interests, and creek property owners about watershed stewardship methods to protect watershed and waterway values.

Facilitate communication and cooperation among various stakeholders concerning watershed issues.

Action Items

- Continue to promote community awareness and support of watershed management issues through newsletters, and riparian and agricultural outreach and educational workshops

- Provide resources and support for interested science teachers in the watershed

- Provide linkages and information to existing world wide web sites focused on SLO watershed issues

As with other action items, the City, County, and Conservancy have active programs for many of the above recommendations. Outreach meetings and dissemination of information on Best Management Practices are requirements of both the Phase II storm water and the TMDL program of the Regional Board.

4.8 Interagency Coordination

Goal. Facilitate on-going communication and coordination among local, state, and federal agencies, non-profit groups, and other watershed stakeholders responsible for management of the natural resources of the watershed

Action Items

- Consider formation of a Coordinated Resources Management Planning (CRMP) team as part of long-term watershed and waterway management efforts (see **Section 5.8).**

  CRMP members could include current Zone 9 Advisory Committee members, and other federal and State agencies currently not a formal part of the Zone 9 Advisory Committee. Zone 9 staff would serve as CRMP staff and provide technical and logistical support.

5. WATERWAY MANAGEMENT PLAN COMPONENTS

5.1 Introduction

This section of the WMP describes the comprehensive program proposed by City/Zone 9 to address the resource problem areas and management needs identified in **Section 3.** The five principal components of this WMP include:

- A **Stream Maintenance and Management Program** (SMMP) covering routine stream maintenance practices and procedures and presenting proposed Best Management Practices (Volume II)
- A new **Drainage Design Manual** (DDM) for stormwater, flood control, and bank repair design (Volume III)
- A **Bank Stabilization Program** (described in this section) that provides a management framework and conceptual plans for addressing current and future bank instability problem areas, and
- A **Habitat Enhancement and Restoration Program** (described in this section), the framework for cooperative stream corridor resource enhancement, restoration, and protection.
- A **Flood Management Plan**, which outlines the conceptual flood control alternatives that are proposed as the Preferred Project (this is described in **Section 6**),

These elements are integrated to meet the stated goals and objectives of the WMP. For instance, general policies for watershed management are included in **Section 4** (Watershed Management Framework) and policies specific to maintenance work in and near streams are contained in the SMMP component, while the Flood Management Plan includes both structural and non-structural elements as part of the proposed solution to address flooding. The designs for structural flood management projects (channel modifications) must utilize the concepts for natural channel design outlined in the DDM The Preferred Project contains both structural and non-structural approaches, including new floodplain management regulations, and the encouragement of flood proofing of existing structures. The SMMP relies on the design procedures for biotechnical bank stabilization outlined in the DDM (to minimize impacts), while mitigation is provided by coordinating enhancement of public and private lands as outlined in the Watershed Management Framework, (**Section 4**) and the Bank Stabilization and Habitat Enhancement elements of the WMP (**Section 5**).

This section reviews the ***Drainage Design Manual***, the ***Stream Maintenance and Management Program*** documents, and the conceptual physical projects and management approach proposed by the City/Zone 9 for flood management, bank stabilization, and habitat enhancement.

5.2 Drainage Design Manual (DDM)

This component of the WMP provides guidance for the planning and design of both public and private storm drain and waterway systems that will be used to convey storm water drainage and flood flows associated with new development and redevelopment projects. The guidelines are intended to ensure that storm drain and waterway systems are designed and managed to:

- Minimize environmental impacts to the creek corridor;
- Avoid or minimize the effects of new development on increased flooding and bank erosion;
- Reduce flood damage (where possible);
- Stabilize eroding banks; and,
- Enhance and restore riparian and aquatic habitat.

In addition to providing criteria for designing open channels and closed conduits (underground storm drains) the DDM also addresses procedures for bank stabilization and flood management facility design, including storm water detention basins, and provides guidelines for erosion control, and for revegetation, restoration, and enhancement of the streamside zone. Erosion control standards are also provided.

Parts of the DDM deal with routine engineering analysis and design of pipes, roadside ditches, drop inlets, and culverts, and represent only minor changes to the existing City and County Design Manuals. Even though they are included in the new DDM, they represent no significant changes to current design procedures.

The DDM replaces both the 1983 City "Flood Policies" book (Pink Book) and recommends revisions to current City and County engineering design standards, for those parts associated with channel, culvert, and storm drain system design, and bank stabilization in the SLO Creek watershed. A section on design of storm water detention facilities has also been included in the DDM. The City and County will need to amend some of their construction standards to be consistent with the DDM.

Current City creek dedication and creek setback policies have not changed. The County currently does not have a creek setback policy for development along creeks in the SLO watershed, and relies on staff recommendations during plan review, and on mitigation measures contained in specific projects and their CEQA documents and permit conditions. No new County creek setback policies are contained in the WMP. A section on Erosion Control and Stormwater Quality Management is included to address the requirements of the Regional Board's Phase II NPDES Stormwater Management Program.

Significant revisions to the current "Pink Book" flood policy and City and County ordinances are summarized in **Table 5-1.** They include:

- Special Floodplain Management Zones
- Managed Fill Policy
- No Adverse Impact Policy
- Channel Classification and Design Guidelines
- Bank Stabilization Guidelines
- Drainage Impact and Stream Zone Impact Fees, and Design Review Fees
- Revised Design Flows
- Erosion Control and Storm water Quality Management
- Revegetation Guidelines
- Channel Maintenance and Management

The following sections summarize the major points of the DDM. It should be noted that the DDM contains a section on "Core Requirements", which represent proposed City and County Policy on flood plain management, stormwater management, and channel design and protection for the SLO Creek watershed. Adoption of the core requirements will mean a higher level of engineering analysis and design, (including project design review) for new projects than is currently required, but a project size limitation has been included to determine when the analysis and design efforts are necessary.

Table 5-1
Creek Policy Revisions

Policy Revisions	Comments
1. Drainage Design Manual a) Create Special Floodplain Mgt. Zone for Mid-Higuera – regulate flow impeding structures	• May also require new City/County Ordinances • Policy included in Mid-Higuera Specific Plan
b) Create Special Floodplain Mgt Zone for Elks Lane area and undeveloped areas along lower SLO and Prefumo Creek with "Managed Fill Policy"	• May also require new City/County Ordinances • Puts burden of proof on developer • Toughens development standards for flooding issues along Elks Lane and southwest of Madonna Road-Hwy 101 • May reduce developable footprint of some sites
c) Adopt "No Adverse Impact" policy making developers demonstrate no hydrologic impacts via new Zone 9 hydrology models	• May also require new City/County Ordinances • Follows recommendations of Association of State Floodplain Managers • Would be one of the strongest floodplain regulations in California • Increases City/County staff review time • Increases design & development costs • Does not necessarily require stormwater detention, but provides design guidelines where used.

Policy Issues	Comments
d) New Creek Classification and Design Policy making it difficult to modify "Natural" creek areas	• Few "natural" areas in City, mostly below LOVR and tributaries
e) New policy of preference for biotechnical bank stabilization designs making use of hard bank structures difficult	• SF District Corps of Engineers Nationwide Permit conditions generally require use of biotechnical designs, although LA District (which SLO is in) currently does not. • Biotech used in Phase I FEMA projects
f) New "Drainage Impact Fee" for new development & "Stream Zone Impact Fee" for Regional mitigation	• May require new City & County Ordinances • Needs follow-up study to set formula for fee collection • About 85% City – "built-out" • Fees applicable only where mitigation not provided
g) New Erosion Control and Stormwater Management Regulations	• Includes provisions for adoption of standard erosion control and stormwater management for small parcel development. • Requires detailed Erosion Control Plans for large parcel development and in critical locations.
2. Stream Maintenance & Management Plan (SMMP) - Adoption of BMP Manual provides permit streamlining but places more responsibility on City & County	• SMMP required by agencies • Provides mechanism for regional mitigation and enhancement • Increase in Design Review Fee may be necessary
3. Design Flows	• Design Flows would guide both City/County sponsored projects and private projects
4. Non-Structural Flood Control (WMP) programs have increased emphasis: a) Wet and Dry flood-proofing b) Building elevation c) Building relocation d) Floodplain acquisition	• Would require additional staff to develop and implement non-structural programs • Would require additional staff to develop a lower CRS, but offsets Drainage Utility fees • Participation is voluntary in FEMA or DWR building elevation, relocation, or property purchase.
5. Bank Repair and Habitat Enhancement (WMP)- Provides mechanism designating recommended biotechnical bank stabilization for 48 mostly private bank failure sties. Private parties agree to design and become part of SMMP subject to Individual Corps permit.	• Bank Repair Program and Habitat Enhancement Element work together with SMMP and Drainage Design Manual in guiding design and mitigating cumulative impacts • No public funds used to construct private repair works, but staff time to coordinate

Throughout the DDM a size standard of 1.0 hectare (2.5 acres) has been used as the development threshold requiring more detailed analysis. This represents a typical 8-10 unit or larger residential subdivision, and many commercial development projects. The City Engineer or County Public Works Director can, however, require more detailed engineering analysis for any project considered to be located in a sensitive area, or if there are significant concerns about the environmental effects of a project, including effects on flooding and bank erosion, or wetlands and stream biology issues.

5.2.1 Special Floodplain Management Zones

Current City and County floodplain management policy allows the importation of fill onto the FEMA defined 100-year floodplain, consistent with FEMA minimum guidelines, up to a point where a maximum 1 foot rise in the 100-year flood water surface elevation occurs. This can occur because of the loss of floodplain storage and the reduction in channel and overbank flow conveyance.

The DDM establishes two new *Special Floodplain Management Zones*, one in the Mid-Higuera area, and one (generally) in the undeveloped lands downstream of Madonna Road and in the lower Prefumo Creek area, as shown in **Figure 5-1.** A *No Net Fill* provision would be applied in this area. Floodplain management policies in the remainder of the developed portions of the City are unchanged, except that a new *No Adverse Impact* policy is proposed watershed-wide.

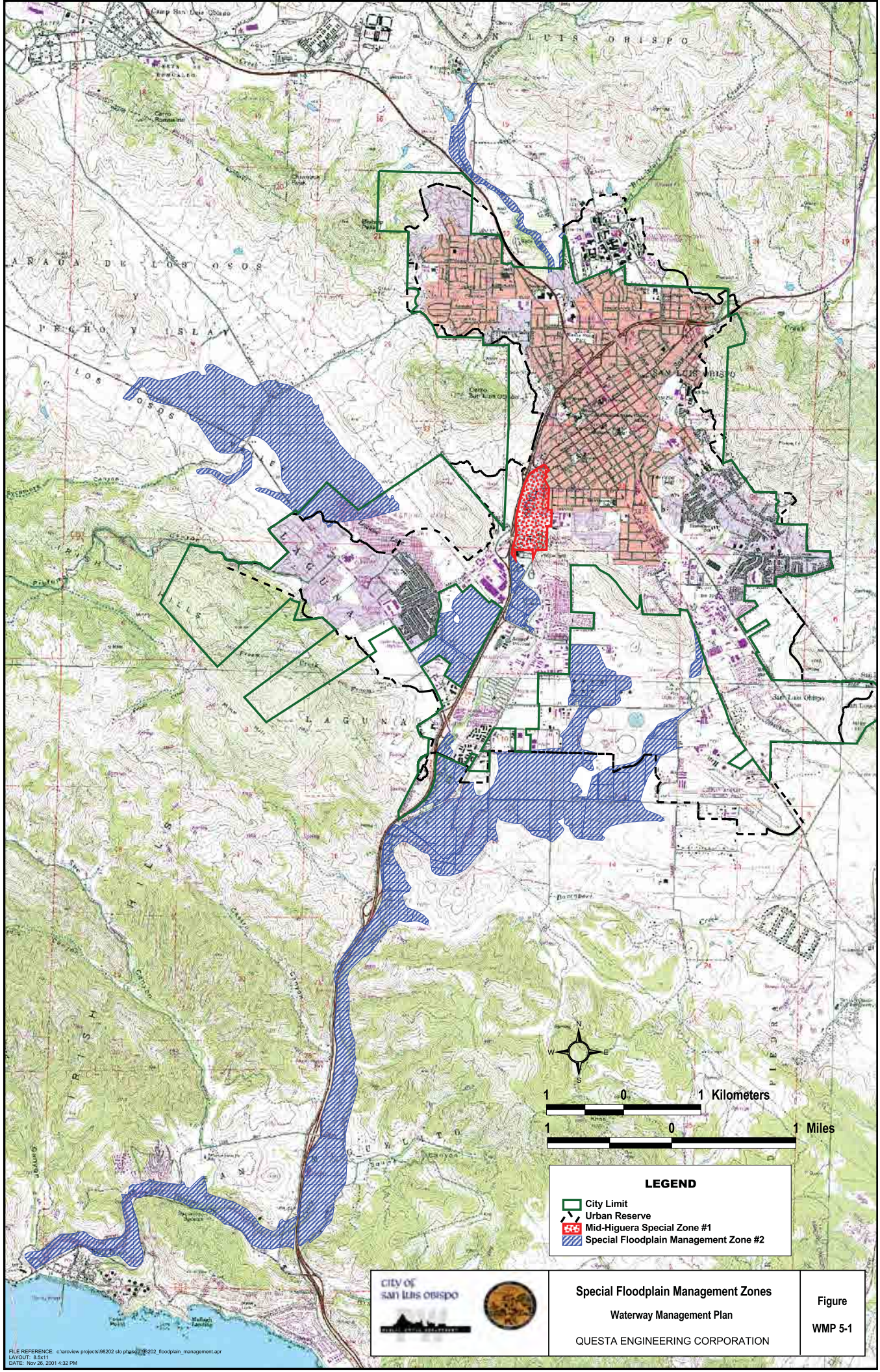
Revised floodplain management policies for the Mid-Higuera Special Zone are proposed to insure that new development and redevelopment does not block overland flood flow conveyance and return flow, such as limiting street medians and fencing and requiring "shadowing" of new buildings. (Note: This policy is already included in the *Mid-Higuera Specific Plan*).

5.2.2 Managed Fill Policy

A *Managed Fill* provision has been added to the City's Floodplain Management Policies for the undeveloped portions of the watershed's principal floodplains in the Madonna Road/lower Prefumo Special Zone. This zone extends downstream from Madonna Road along SLO Creek all the way to Avila Beach, as well as the undeveloped floodplain areas along Prefumo Creek and in the Laguna Lake area. This policy would minimize the impact of development on loss of floodplain storage and consequent higher flood flows by requiring that fill for elevating portions of a property above the 100 year flood come from excavation of other portions of the property within the floodplain, generally. This is shown diagrammatically in **Figure 5-2**. Implementation of this policy will require more creativity and careful design in floodplain areas to insure that projects do not create upstream or downstream flooding and bank erosion problems. It may affect the acreage of developable area on a given parcel. The policy will also necessitate more comprehensive design review by City and County staff.

5.2.3 No Adverse Impact Policy

A *No Adverse Impact* policy is proposed for the entire SLO Creek watershed to insure that future development and redevelopment does not cause additional flooding, bank erosion, or habitat destruction. The *No Adverse Impact* policy is modeled after the policy contained in the Association of State Flood Plain Managers (www.floods.org) position paper on this issue. The new Zone 9 computer hydrology and hydraulic models would be utilized by project applicants to demonstrate that a project design does not have an adverse impact. The models can predict changes in runoff, downstream water surface flood elevation, stream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Urban Reserve
Mid-Higuera Special Zone #1
Special Floodplain Management Zone #2
city of
san luis obispo
Special Floodplain Management Zones
Waterway Management Plan
QUESTA ENGINEERING CORPORATION
Figure
WMP 5-1
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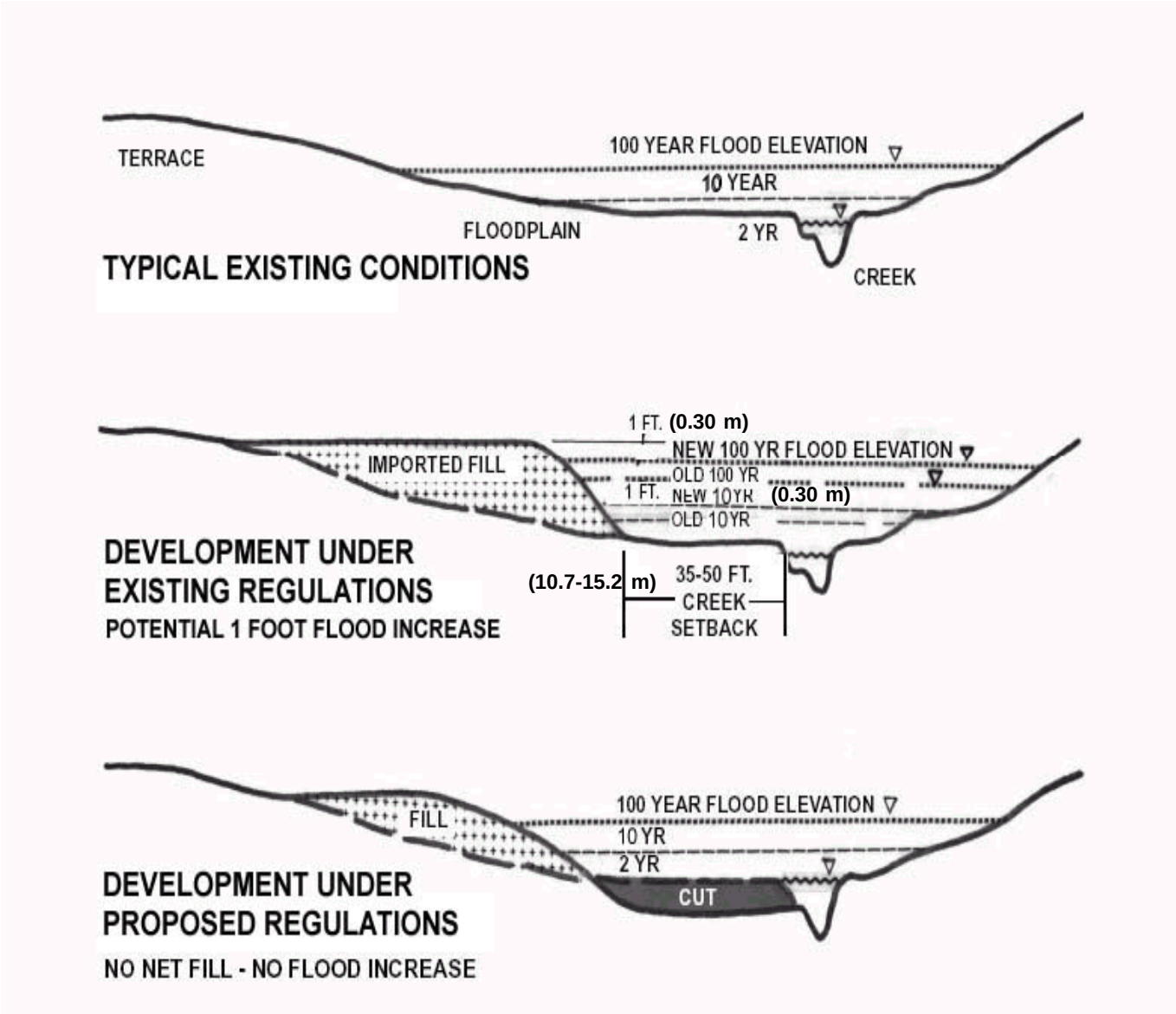

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No Net Fill

Waterway Management Plan
City & County of San Luis Obispo

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Figure

5-2

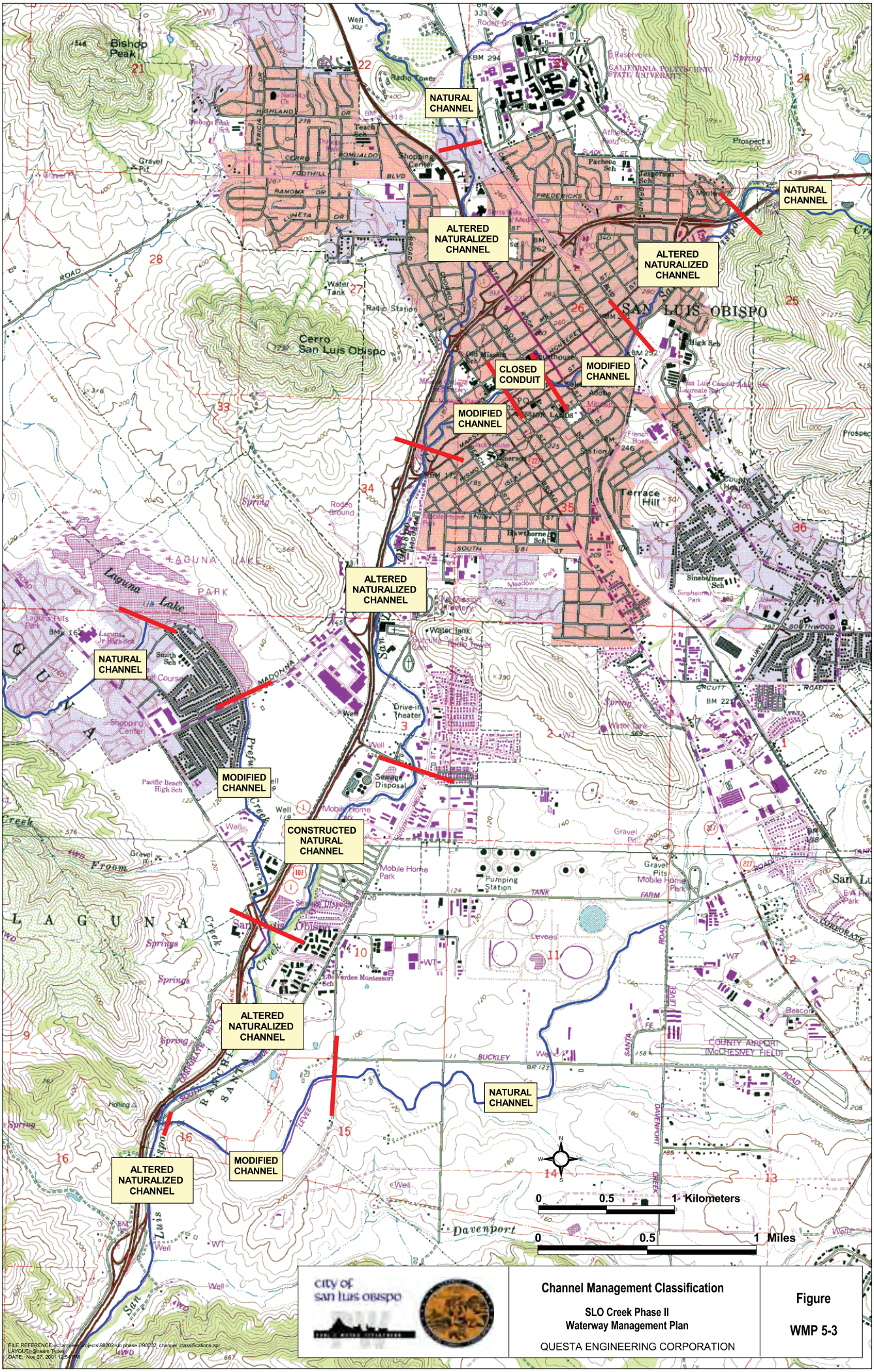
velocities and shearing forces (predictors of possible bank erosion) following development. These would be compared to the capacities and tolerances of existing channel conditions to determine potential impacts. It should be emphasized that the "No Adverse Impact" policy does not necessarily require an on-site stormwater detention basin to facilitate no net increase in runoff. The focus is on determining and mitigating impacts of increased runoff, recognizing that on-site stormwater detention may not be needed or even recommended in some lower portions of the watershed.

Project applicants would also complete a detailed review of project impacts on stream biology and geomorphology. The policy exempts very small residential and very small commercial development projects from this analysis. As with the *No Net Fill* provision, implementation of this policy will require a higher level of hydrologic design analysis by project applicants and a more comprehensive review by City and County engineering staff.

The applicant would be required to mitigate identified adverse impacts, such as downstream flooding and drainage, due to lack of conveyance capacity, or bank erosion and channel instability. This might mean that the project proponent must construct an on-site storm water detention facility (for flood management, not necessarily water quality management), improve drainage system conveyance, or stabilize and restore on-site or downstream channel segments. If it is not feasible or practical to mitigate impacts on-site or in the immediate project area, then the proposed policies call for the City and County to impose an *impact fee* to help fund regional mitigation projects, such as regional stormwater detention basins. All such projects would be subject to additional environmental review.

5.2.4 Channel Design and Bank Stabilization Guidelines

The DDM includes a channel management classification system, identifying creek reaches based on existing conditions and the degree of prior disturbance (**Figure 5-3**). The DDM makes it more difficult to propose work that will disturb or significantly modify creeks with good habitat conditions, and provides guidelines to restore and enhance disturbed creek areas associated with new development projects. All of the creek reaches that are considered in good condition are located in undeveloped areas. Specific geomorphically and biologically sound channel design guidelines are included where channel modification is required (and approved in subsequent environmental and permit review). The design guidelines provide criteria for creating a geomorphically stable and biologically diverse stream environment with a summer low flow channel, pools and riffles, natural meanders, vegetated in-channel benches and floodplain terraces. This approach is sometimes called "*Natural Channel Design*", and the resultant channel termed a *"Constructed Natural Channel"*. An example of a constructed natural channel is provided in **Figure 5-4**. In some areas the use of flood "*Bypass Channels*" is recommended (**Figure 5-5**). A bypass channel retains the thread and integrity of the existing channel by constructing a secondary (generally parallel) channel with a vegetated berm or undisturbed strip separating the natural channel from the bypass channel. The secondary channel is constructed with the channel bottom elevation higher than the natural channel so that only flood flows over a certain discharge (e.g. greater than 2-year recurrence interval) move through the secondary channel. This preserves the critical summer low flow regime of the main channel and allows a certain



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Channel Management Classification

SLO Creek Phase II
Waterway Management Plan

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Figure

WMP 5-3

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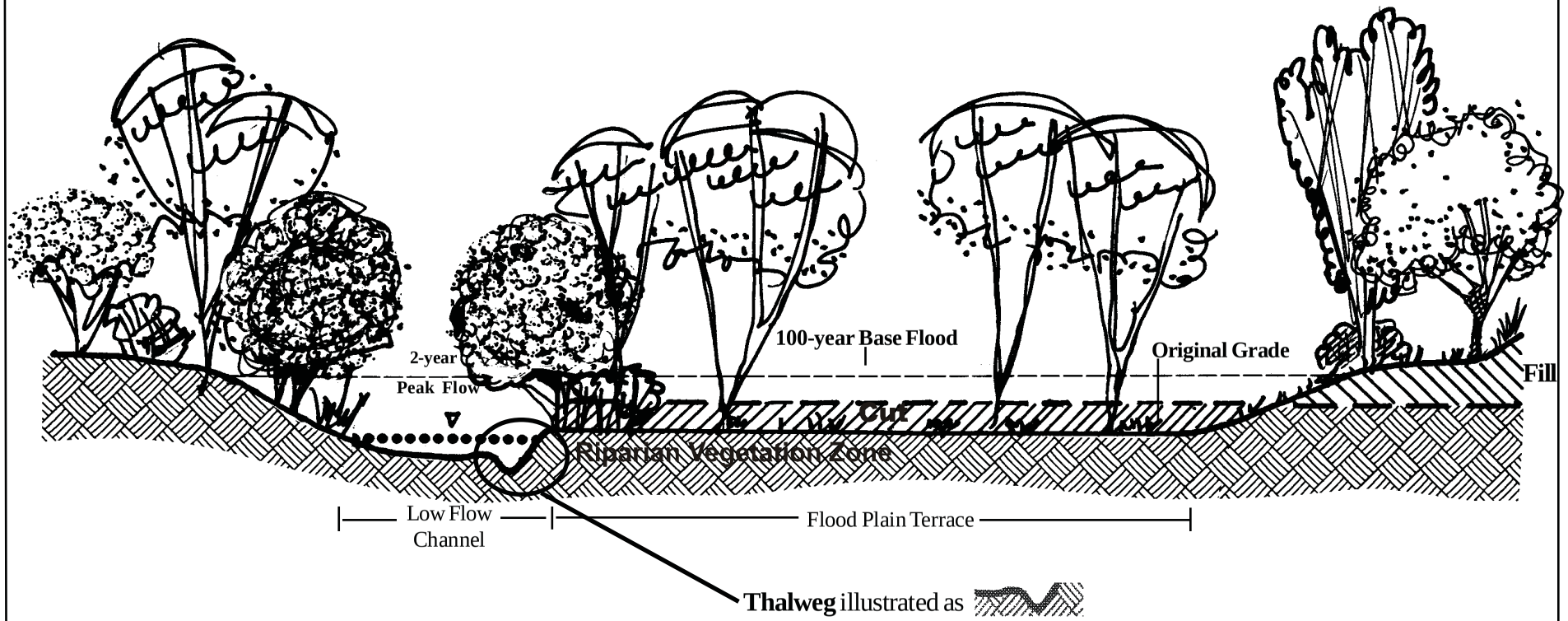

Constructed Natural Channel

Waterway Management Plan
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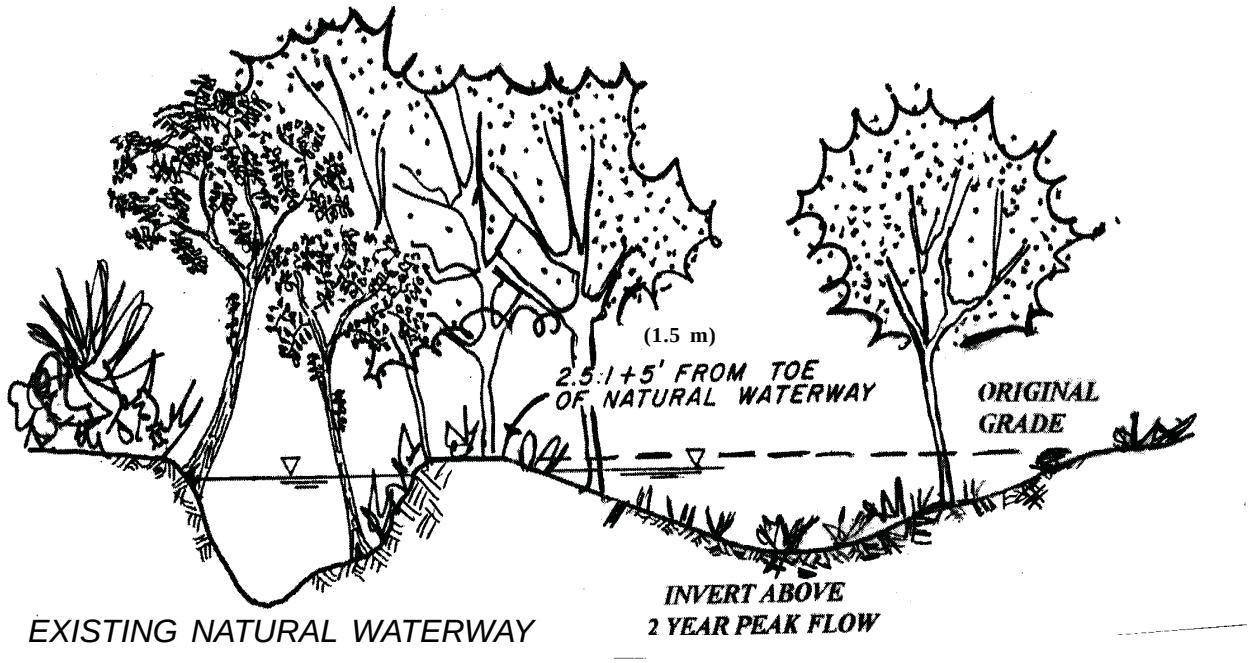
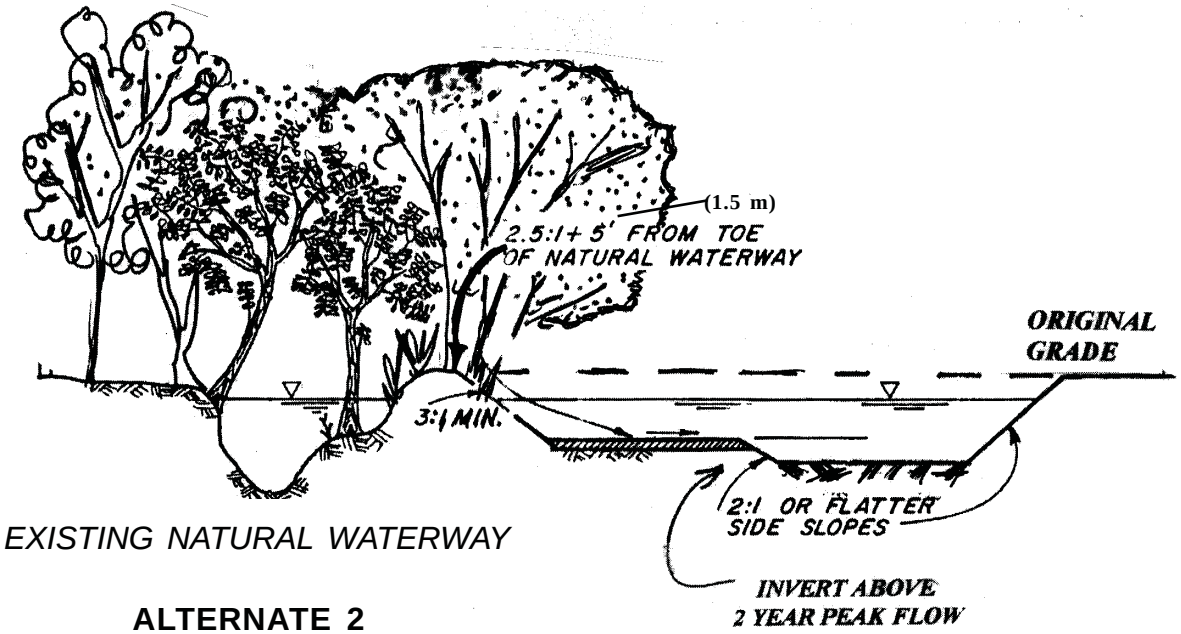
Figure
5-4

BYPASS SYSTEMS



ALTERNATE 1
CONSTRUCTED SECONDARY CHANNEL



ALTERNATE 2
RESTORED FLOODPLAIN

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Bypass Systems

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Figure

5-5

amount of flooding to occur, which is important to maintain natural channel biologic and geomorphic functions.

5.2.5 Bank Stabilization and Revegetation

The DDM presents guidelines for bank stabilization and revegetation. For most projects the design approach requires hydraulic and geomorphic analysis of the bank failure site, to understand the cause of failure, and to determine channel velocities and shearing forces for selection of the most appropriate channel lining and protection material. The City/Zone 9 hydraulic model and the stream inventory data contain most of the information needed to complete the analysis. The objective of the analysis is to aid in the selection of the softest, most well vegetated approach to bank stabilization, consistent with sound engineering practice. In most cases biotechnical approaches to bank stabilization are emphasized along natural creek areas, with structural approaches generally limited to urban creek reaches where lack of room at top of bank and difficult geotechnical problems require use of harder materials.

5.2.6 Drainage Impact, Stream Zone Impact Fees, and Design Review Fees

The DDM recommends that the City and County consider the imposition of impact fees on some types of new development to fund City and County floodplain management programs. Impact fees would be collected for projects that do not adequately mitigate their impacts on-site. California law governs imposition of impact fees; fees must be tied directly to impact levels and the costs of administering the impact fee program. Impact fees can only be used to mitigate specific project impacts.

Drainage Impact Fees would be one-time charges assessed to compensate for impacts to the system of creeks and drainage structures that are otherwise not mitigated by an applicant. They would be tied to either a measure of impervious surface area, or increase in storm water runoff. The impact fee would likely require revisions to the City and County Codes.

The fees could be used to fund drainage improvements along waterways or the construction of regional stormwater detention/retention facilities.

Stream Zone Impact Fees would be tied to biological impacts to the wetlands and riparian areas along a creek. Impacts for fee assessment would be measured in lineal meters (or feet) along a stream. Stream Zone Impact Fees would assist the City and County in implementing Stream Habitat Enhancement projects as mitigation for the SMMP.

One advantage of such a program is that it enables a regional perspective in selecting and designing mitigation sites. This can result in the consolidation of numerous small, isolated or fragmented mitigation projects with limited and localized environmental values into larger, managed parcels with greater ecological benefit.

The DDM will require engineers and planners to perform a more detailed analysis (than currently required) along creeks and floodplains, and will require a greater amount of technical review by City and County staff. This will add staff time. The City will also need

to periodically update and maintain the Zone 9 computer models. An increase in *Design Review Fees*, including use of cost recovery for projects located along creeks and flood prone areas, is anticipated.

5.2.7 Revised Creek Design Flows

A100-year flood protection designation is often used as a standard in flood design, yet this standard cannot be achieved in some communities. It may be infeasible because of costs or environmental impacts in many areas of the SLO watershed. Proposed *Design Flows* are contained in the DDM. They will be used for flood management planning. Designation of an alternative Design Flow (50 vs.100- year design flow in a stream reach) in the WMP will direct the selection of the structural flood control alternative needed to meet the design flow objective. In general, the higher the Design Flow, the greater will be the project size (channel modification or enlargement), with more environmental impacts. (Use of flood bypass channels does, however minimize impacts to the channel environment). Where channel modification is necessary and approved consistent with subsequent CEQA review, the channel should be enhanced and revegetated using native plant materials. Higher project costs will also be incurred in achieving them, although not necessarily in a direct relationship with project size.

Table 5-2 summarizes the proposed Creek *Design Flow* for the various reaches of streams within the SLO Creek watershed.

Table 5-2
Channel Design Flow Requirements[1]

Waterway	Design Flow
Major Waterways within the City of SLO	
SLO Creek above confluence with Stenner Creek	40 year[2]
SLO Creek below confluence with Stenner Creek to Madonna Road	20 year
SLO Creek from Madonna Road to Prado Road	50 year
SLO Creek from Prado Road to confluence with Prefumo Creek	100 year
SLO Creek from Prefumo Creek confluence to City Urban Reserve Line	100 year
SLO Creek below City Urban Reserve Line – maintain existing capacity	(aprx 10-year event for much of reach)
East Fork from SLO Creek to Broad Street3	varies- see footnote **3**
SLO Creek from Prefumo Creek confluence to Urban Reserve Line	100 year
Stenner Creek from SLO Creek to Chorro Street	50 year
Stenner Creek from Chorro Street to Urban Reserve Line	100 year
Prefumo Creek within Urban Reserve Line	100 year
Old Garden Creek within Urban Reserve Line	25 year
Other Major Waterways[4]	50 year
Secondary Waterways[5]	25 year
Minor Waterways[6]	10 year

Notes:

1. For purposes of designating Design Flows, the required design capacities and design requirements, the system of creeks and waterway in the SLO watershed is divided into major, secondary and minor waterways. All existing and proposed conveyance systems shall be analyzed and designed using the peak flows fro the hydrographs developed per the procedures described in Section 4 of the Drainage Design Manual to meet the design capacities.
2. 100-year protection can be provided with the Cuesta Park Detention Enhancement project.
3. East Fork of San Luis Obispo Creek is included in the Airport Area Specific Plan. Standards and plans for flood management are included in the plan and related environmental documents.
4 **Other Major Waterways** not named above and within the City Urban Reserve Line, or outside the City that have a drainage area of over 10 km^2 (4 square miles) shall be designed for an average recurrences interval of 25-years with 0.6-m (2-ft) of freeboard, and shall have sufficient capacity for a 50-year design discharge either by alternate surface routes (such as shallow street flow) or be contained within the channel without freeboard.
5. **Secondary Waterways** have a drainage area between 2.6 km^2 to 10km^2 (1 to 4 square miles) and shall be designated at a minimum storm recurrence interval of 10-years, with 0.3-m (1-ft) of freeboard.
6 **Minor Waterways** have a drainage area of less than 2.6 km^2 (1 square mile) and shall be designated at a minimum storm recurrence interval of 10-years, with 0.3-m (1-ft) of freeboard.

5.2.8 Erosion Control and Stormwater Quality Management.

This provision of the Core Requirements updates and strengthens current City and County Grading and Erosion Control ordinances, and includes erosion control as a part of the City and County Drainage Standards. As with most of the Core Requirements, a 1.0-hectare (2.5-acre) project size triggers the requirement for detailed erosion control planning and design analysis, and places greater restrictions on design and construction practices on parcels above that size. Steep slope areas (above 15% slope), and many sensitive areas along streams and near wetlands are included in this provision requiring detailed erosion control planning.

This Core Requirement outlines *Standard Erosion Control Measures* to be utilized to minimize or control soil erosion and sedimentation for smaller parcels (0.4-1.0-hectare, or 1.0-2.5-acres). Parcels smaller than 0.4 hectares (1.0-acre) are not covered by the specific requirement for erosion control planning, although the City, County, or Regional Board can still cite gross offenders under other local and state rules and regulations. This size standard will need to be lowered to 0.4-hectares (1.0-acre) when Phase II storm water regulations go into effect in the urban portions of the watershed in 2003 or 2004.

The Standard Erosion Control Measures may be implemented directly by the property owner or construction contractors without the need to prepare a detailed erosion control plan. In addition, this provision of the Core Requirements restricts the discharge or washing of common construction materials and by-products into the storm drain system, such as the clean up of paint brushes, painting equipment, and clean-up of concrete forms and poured concrete structures.

A detailed *Soil Erosion and Sediment Control Manual* has not been prepared as part of the development of the DDM. Instead, the DDM refers to the San Francisco Bay Association of Bay Area Governments (ABAG) *Manual of Standards for Erosion and Sediment Control Measures* (second edition, May 1995), and *Erosion and Sediment Control Field Manual*, available from the San Francisco Bay Regional Water Quality Control Board.

The Drainage Design Manual also provides Best Management Practices for construction related stormwater management, drawn from the CalTrans Best Management Practices Stormwater Manual. These measures will be required to be implemented for all projects in the SLO Creek Watershed that required a City or County issued building or grading permit.

5.2.9 Channel Maintenance and Management

This element of the Core Requirement means that project applicants must develop and implement plans to maintain, monitor, and manage all drainage facilities and hydraulic structures, and that such structures must be functioning correctly prior to their dedication to the City or County. Such structures include detention basins, channel modifications, and bank stabilization devices, as well as public storm drains. Where a regulatory agency has imposed mitigation requirements (such as bank top planting) in an area that will be dedicated to the City or County, the mitigation measure must be accepted as complete by all appropriate agencies before the City or County will consider acceptance of dedication. The maintenance and management plan must be consistent with the SMMP.

5.3 Stream Maintenance and Management Program (SMMP)

This WMP focuses on developing new and better methods for routine maintenance and management of the stream corridor. This includes:

- Management of aggressive exotic plant species,
- Selective management of native vegetation such as shrubby, dense willow growth that can interfere with flood flows in urban areas,
- Management of sediment accumulation and debris blockages, such as downed trees, and,
- Management of bank erosion problems, including repair of failing structures.

This component of the WMP is contained in a separate document entitled *SLO Creek Stream Management and Maintenance Program for the San Luis Obispo Creek Watershed* (SMMP). This document includes a specific set of watershed Best Management Practices for work in stream corridors, and incorporates by reference the *Channel Maintenance Best Management Practices Manual* developed in 2000 by the Bay Area Storm Water Management Association (BASMA). The important parts of the SMMP have been abstracted for inclusion here as part of the WMP report.

The SMMP is a “Policies and Procedures” document. It presents policies for management of creek resources, and contains Best Management Practices (BMPs) describing how the City and County will perform routine maintenance such as willow management and repair of bank failures. The SMMP will lead to a probable Memorandum of Understanding with the ACOE and other State and Federal Agencies, including the issuance of an Individual Permit for work within stream channels that are considered jurisdictional wetlands.

The intent of the SMMP is to increase efficiency in the permit review and approval process (and compliance with environmental regulations) by making the City and County responsible for the review and monitoring of routine maintenance projects, including follow-up assessment to ensure that the conditions of approval and mitigation requirements have been met.

The SMMP applies to public projects as well as projects proposed by private citizens, who elect to become a part of the Program. To take advantage of this Program, private property owners will be required to contribute to the preparation and submittal of an Annual Work Plan (AWP) by City/Zone 9, for certain kinds of projects. Routine projects that are currently considered CEQA/NEPA exempt and that do not currently require ACOE permits can proceed as before, and need not be included in the AWP. Large projects that require Individual ACOE permits will continue to require such permit review. The focus of the AWP will be on those projects that currently require a Nationwide permit from the ACOE, and consultation on Endangered Species issues with the U.S. Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS). Those private parties who do not wish to be a part of the City and/or County Programs will need to go through a separate Individual permit process, along with permit applications to CDFG, and the Central Coast Regional Water Quality Control Board.

The Central Coast Regional Water Quality Control Board's Basin Plan (Section V.6.4) may also be applicable to construction practices and project designs, such as for bank repair. The Basin Plan will be incorporated into project design and design review of SMMP projects, as well as other development related construction projects along the creek, which will follow DDM design criteria. For instance, the Basin Plan states,

> *"a filter strip of appropriate width shall be maintained wherever possible between significant land disturbance activities and water courses…For construction activities, a minimum width of the strip shall be thirty feet, as measured to the highest anticipated water line…"*

Detailed vegetation and woody debris management, and stream bank repair policies and procedures are included in the SMMP. To determine vegetation management needs, stream reaches will be surveyed and trees marked for subsequent management (or protection) by a team consisting of a biologist and hydrologist. Creek activities will be completed by trained crews using an agency approved Maintenance Manual, which is provided as an Appendix to the SMMP. Management actions may include tree removal, thinning, and limbing to reduce the flow restrictive influence of the lower streamside trees. Tree removal, thinning and limbing to increase flood flow conveyance will focus on constricted areas and channel choke points within developed areas that experience recurrent damaging flooding, such as the Mid-Higuera area. Priority will be given to removal of non-native species and hazardous trees, or those that are undercut, diseased or dead and in danger of toppling into the creek. Where native hazard trees can be saved, provide snag habitat, or are undercut but provide valuable stream cover, alternative methods such as cabling and anchoring will be considered before removal.

In some areas, exotic trees such as Eucalyptus and Monterey Cypress line the bank top and shade out more desirable native understory plants. Tree removal may be phased in over a period of years, associated with replanting natives such as sycamores, oaks, and cottonwoods.

The goal of vegetation management is to create a closed tunnel-like canopy by encouraging larger, single trunk native trees to provide shade for stream temperature management and reduce growth of flow restrictive vegetation. Work may include selectively thinning dense willow growth on the lower banks, and limbing up selective trees, removing most limbs below 5-6 feet high. Trees growing over pools and mature native trees will be preserved. Some areas of dense willows, undercut trees, and snags will be retained for habitat value. Typical vegetation management techniques that will be used are shown in **Figure 5-6.**

In-stream habitat will be improved in areas where intensive vegetation management is completed to compensate for removal of shrubby streamside willows and mature exotic trees. Habitat improvement may include the installation of rock boulders to create new pools, artificial cover and habitat structures such as boulder clusters, (**Figure 5-7)**, root wads (**Figure 5-8**) or Lunker structures (**Figure 5-9**). Lunker structures consist of wood structures (similar in size and shape to a small to large coffee table) that are installed at the toe of creek near pools to provide fish shelter. They are usually cabled in place or anchored with rocks surround and over them, and planted. Gaps in the tree canopy and upper bank slopes will be inter-planted with native trees and shrubs as part of the stream management work.

Bank repair will focus on use of soil bioengineering techniques such willow wattles, planted geogrids, planted rock riprap, coir biologs and erosion blankets, and live crib walls. **Figures 5-10 through 5-14** provide examples of some of the kinds of biotechnical engineering designs for bank stabilization in the SLO Creek watershed.

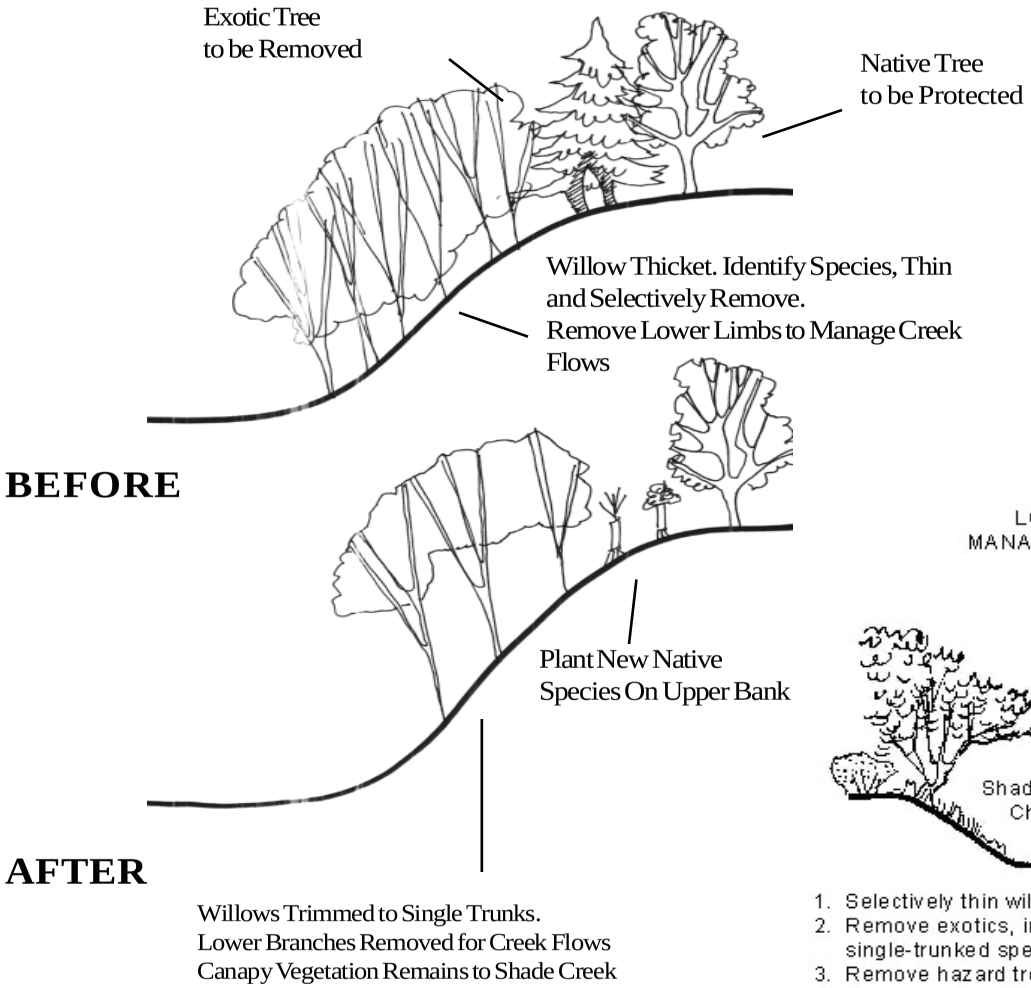
5.3.1 Environmental Issues addressed in SMMP

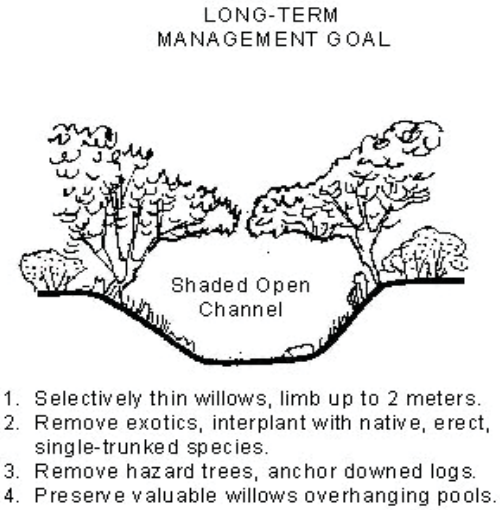
The SMMP provides procedures to avoid and minimize impacts to cultural, biological and other resources, including wetlands, riparian and aquatic habitat. Many streamside habitats support sensitive wildlife and aquatic species that have the potential to be affected by management and maintenance activities. Activities such as vegetation removal or earthwork may also affect the geomorphic (bank stability) and hydrologic (water movement and flooding) function of the creek system. The SMMP recommends a planning and design approach based on more complete hydrologic and geomorphic analysis than is currently being utilized for project planning and design, and use of Best Management Practices (BMPs) to minimize and mitigate environmental impacts.

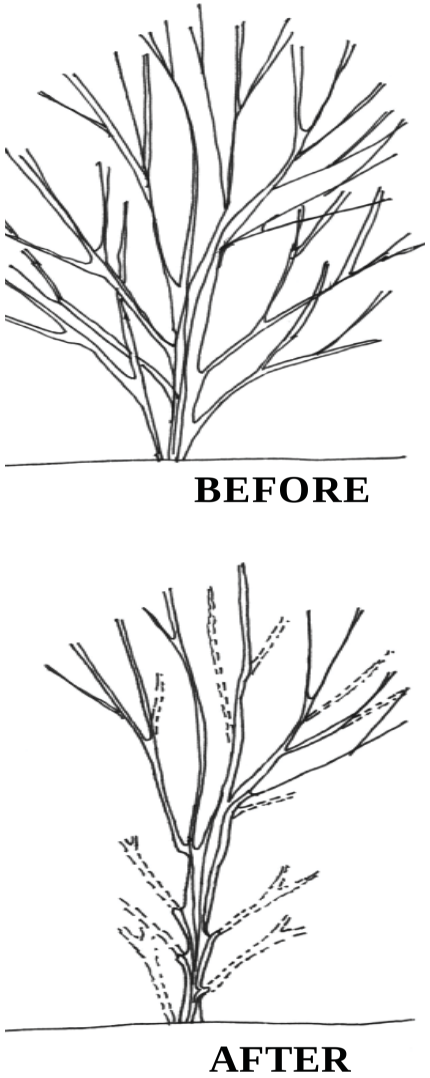
5.3.2 SMMP Program Approach

The SMMP uses a tiered, or three (3) level or category approach to planning, project review, and implementation. A simple notification procedure will be used for most routine projects. Use of approved BMPs, self-monitoring by City and County Planning and Engineering staff and verification of work in “as-built” plans are also central to the program approach.

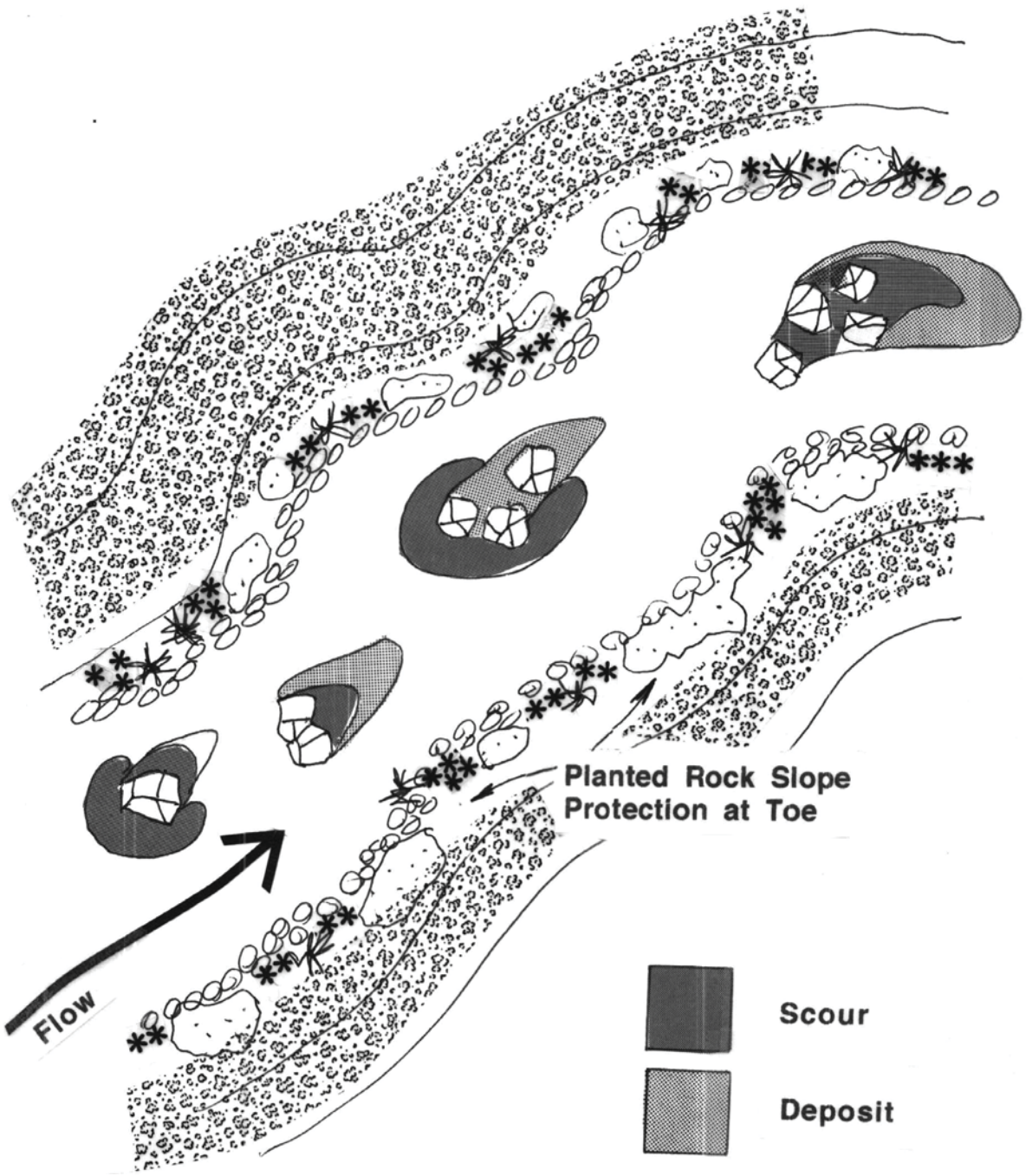
Category 1, *CEQA Exempt* and *Low Impact* Projects do not require a ACOE permit. This includes projects such as culvert cleaning, willow thinning, and maintaining or repairing existing bank protection structures using similar materials. California Department of Fish







city of san luis obispo PUBLIC WORKS DEPARTMENT 955 MORRO ST. 93401-3208	**Vegetative Management** Waterway Management Plan City & County of San Luis Obispo QUESTA ENGINEERING CORPORATION	Figure **5-6**



Boulder Clusters

Waterway Management Plan
City & County of San Luis Obispo

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Figure

5-7

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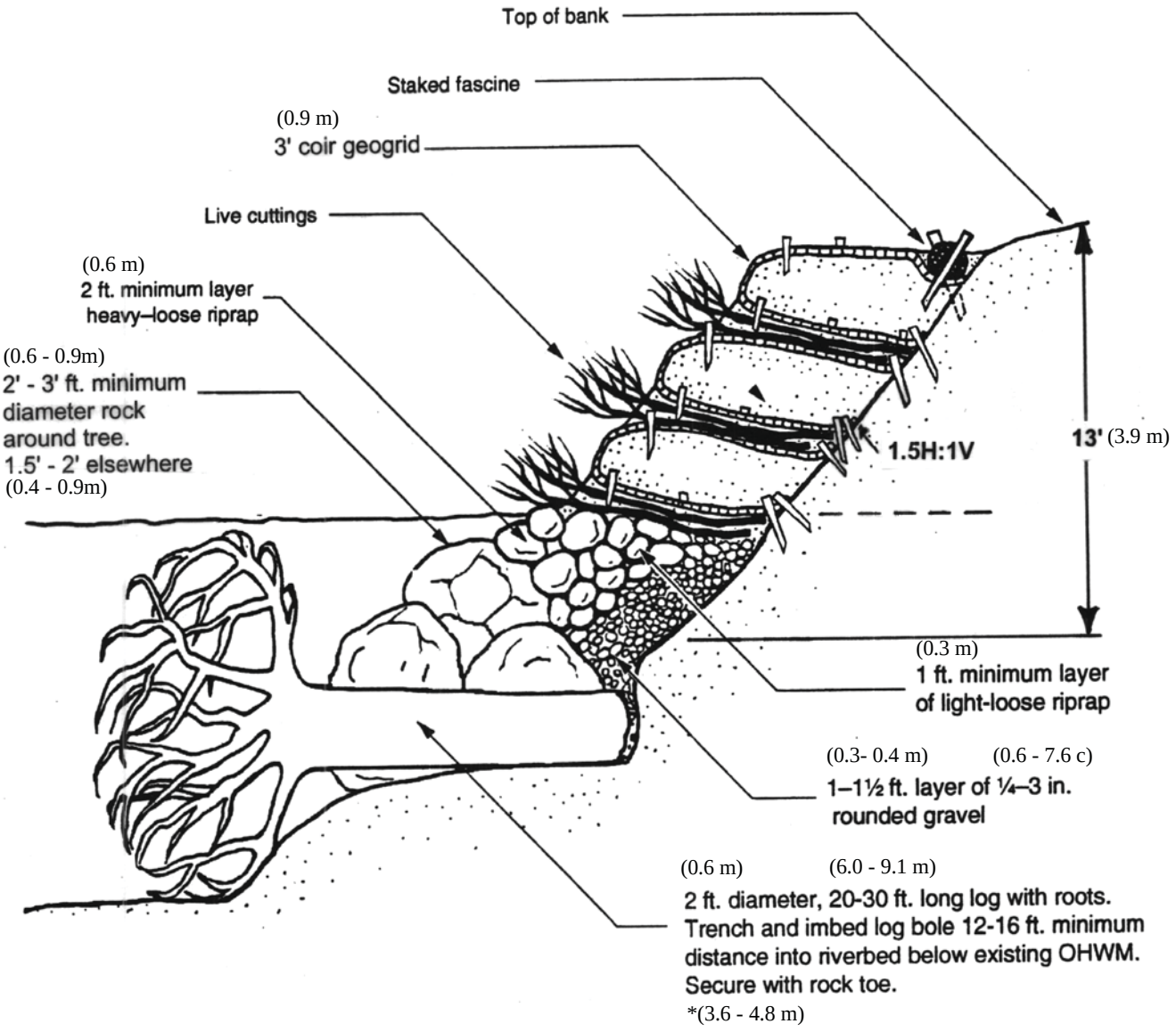

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Rootwad/Geogrid

Waterway Management Plan
City & County of San Luis Obispo

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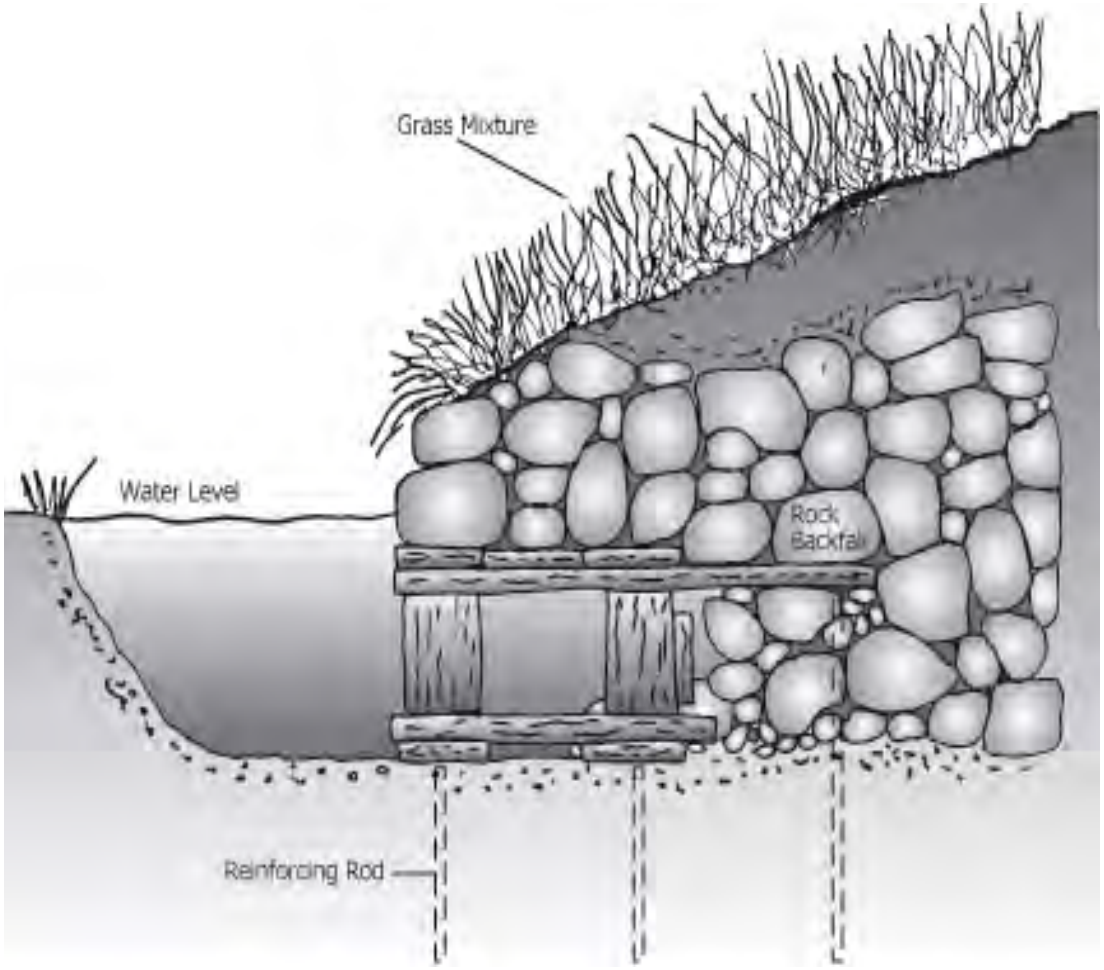
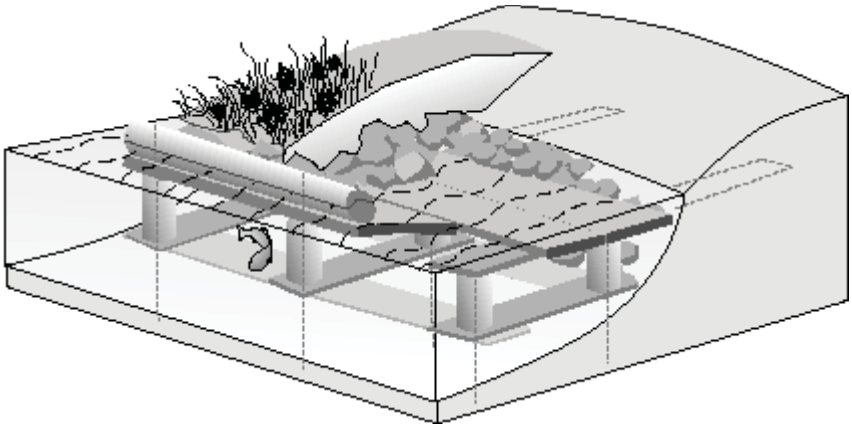
Figure

5-8



Based on illustration from Vetrano 1988. Used w/permission



"Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

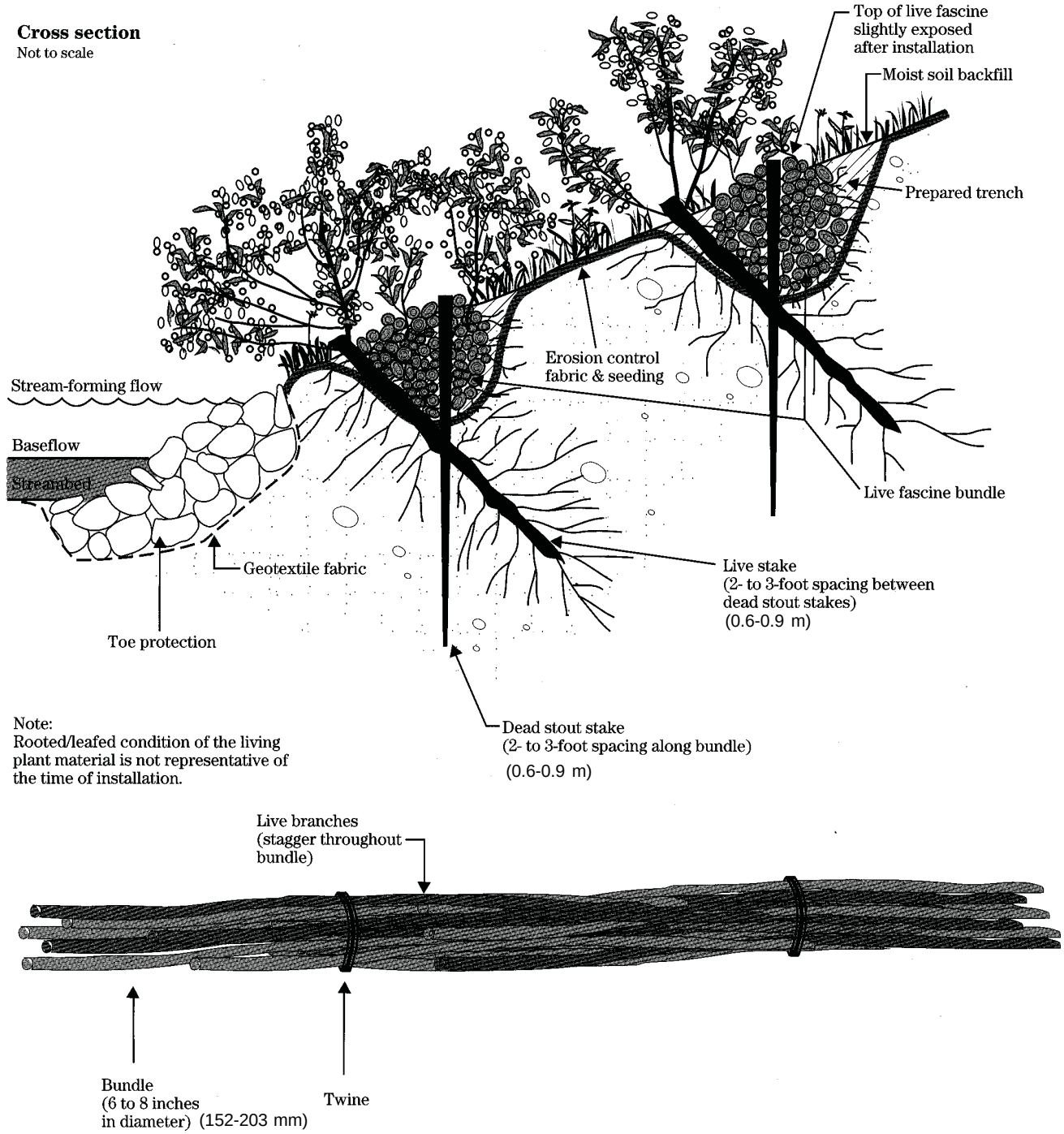
Lunker Structure

Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure

5-9



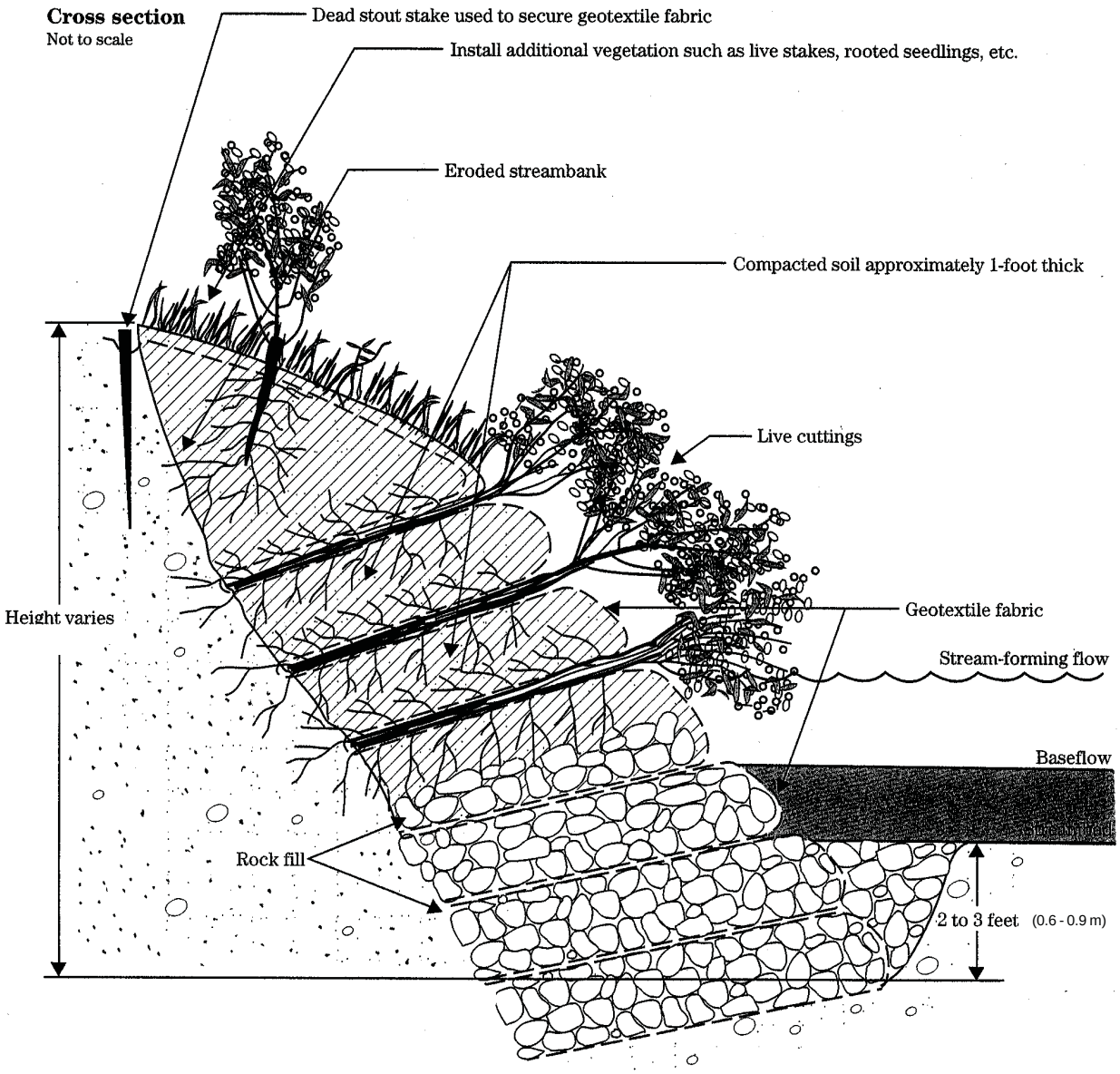
Live Stakes and Willow Wattles

Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure

5-10



Note: Rooted/leafed condition of the living plant material is not representative of the time of installation.

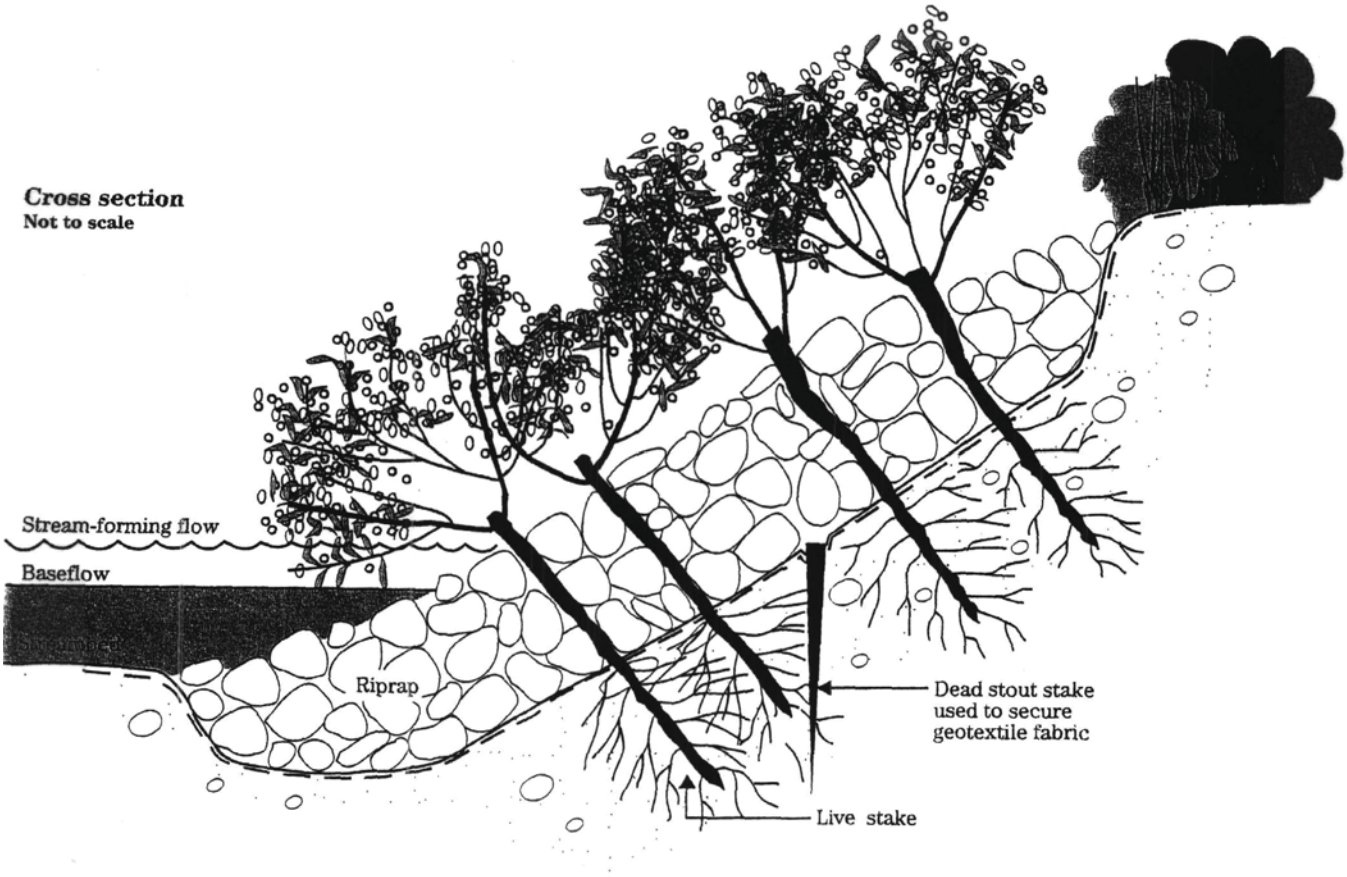
Geogrid

Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure

5-11



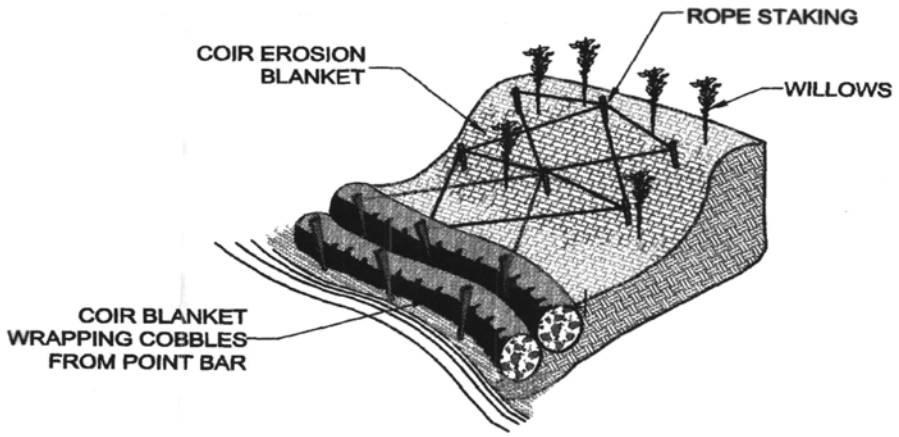
Planted Rip Rap

Waterway Management Plan
City & County of San Luis Obispo

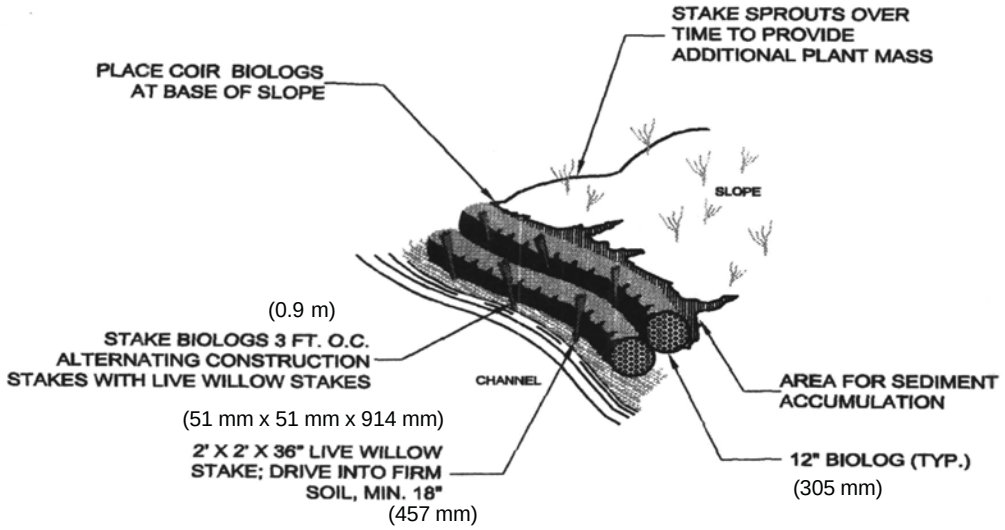
QUESTA ENGINEERING CORPORATION

Figure

5-12

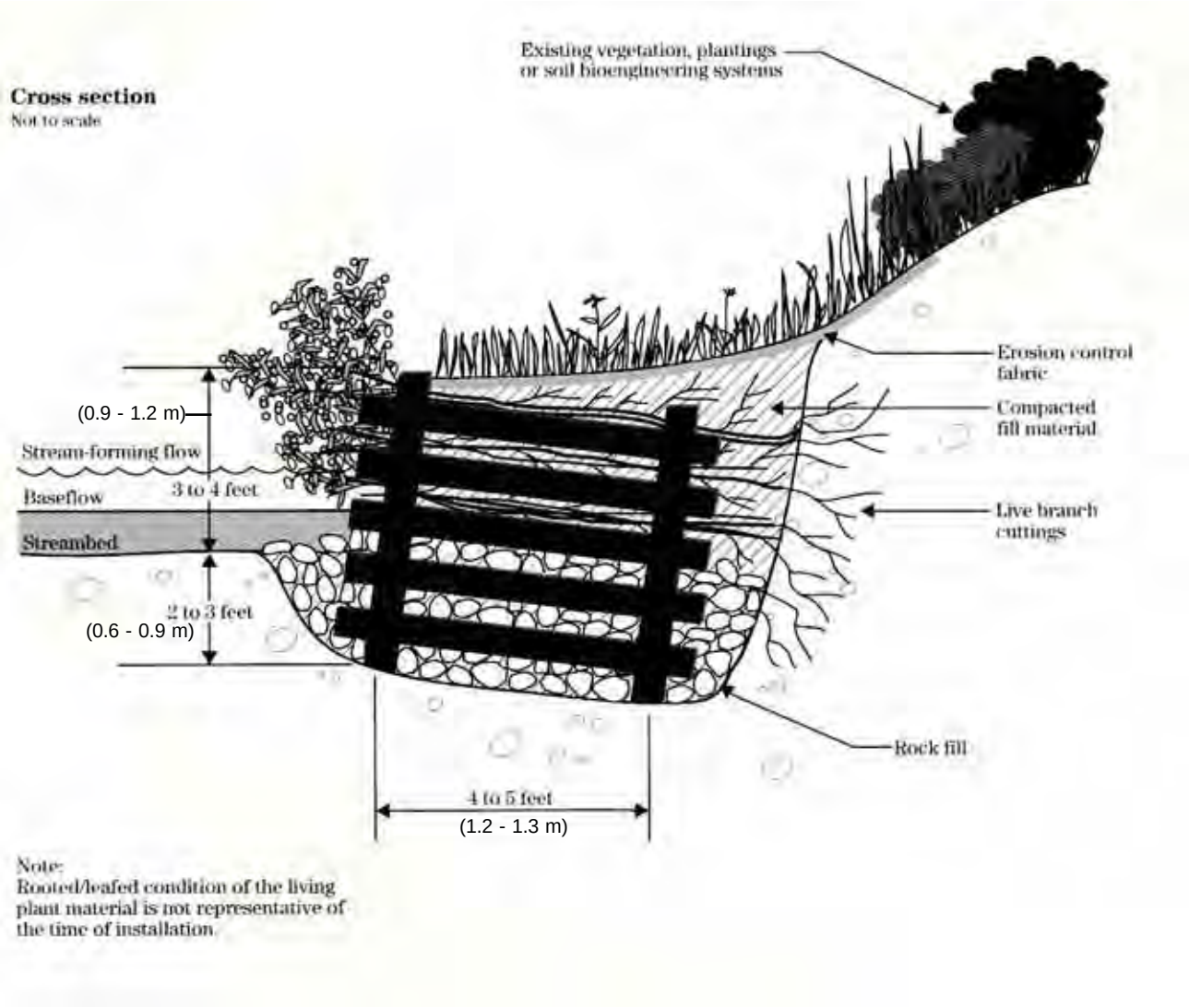


FIBER ROCK ROLL



BIOLOG TOE PROTECTION

city of san Luis obispo PUBLIC WORKS DEPARTMENT 955 MORRO ST. 93401-3208	Coir Logs **Waterway Management Plan** **City & County of San Luis Obispo** QUESTA ENGINEERING CORPORATION	Figure **5-13**



city of san luis obispo

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Live Crib Wall

Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure

5-14

and Game biologists will be routinely consulted on projects that involve vegetation management and removal of large woody debris.

Category 2, *Minor Impact* Projects may require a ACOE Nationwide Section 404 permit. For these projects, an Annual Work Plan (AWP) will be prepared, based on an annual maintenance and management needs reconnaissance and assessment. The inventory data may be entered into a maintenance layer of the San Luis Obispo Phase II Project Geographic Information System as this system continues to be developed. The AWP will incorporate procedures, policies and BMPs outlined in this Program. The AWP will be reviewed by the City/County environmental officer for compliance agency permit conditions and with mitigation measures included in the Programmatic EIR/EIS. The compliance officer may recommend additional technical studies, environmental review, a change in practices, or additional mitigation. A public meeting will be held by Zone 9, and after approval at the local level, the AWP will be submitted to regulatory agencies for review. Additional requirements, including individual permit review and extra compensatory mitigation may be imposed by the regulatory agencies for those elements of the AWP judged to be outside of the approved Program.

Category 3 *Major Projects* include those with potentially significant impacts; such as bridge replacement and flood control channel modifications (requiring individual ACOE permits) are not included in this Program. These projects will still require a specific or Individual ACOE permit, and consultation with the US Fish and Wildlife Service and National Marine Fisheries Service on endangered species issues.

5.3.3 Mitigation for SMMP Activities

The SMMP provides an approach to vegetation management that involves the phased, gradual conversion of plant communities with exotic vegetation and shrubby willows (with high flow resistance), to a plant community composed of larger, single trunk native trees that shade the channel and have lower frictional resistance to flow. However, the Program also recognizes the special biological values of willow shrub communities, and requires that willow management for flood hazard reduction purposes be justified. Not all willow communities along the creeks will be managed for flood reduction, and Fish and Game biologists will be consulted on vegetation management projects. Normally, the need for extensive vegetation and sediment management will be dictated by hydraulic analysis of the stream conveyance system, with work prioritized in areas of most need (least flood flow capacity to achieve designated flood conveyance in urban flood prone areas). This may be difficult to achieve in many reaches.

Work would generally be completed in management units on alternating sides of the bank and be staged over a period of years to reduce short-term biological impacts. Restoration and biological enhancement of work areas should be included in each project element of the AWP. This includes riparian restoration and enhancement of aquatic habitat by creating new scour pools and hiding habitat, using structures such as rock boulder clusters, root wads, and Lunker structures. These structures will be designed in accordance with Programmatic permit conditions and adopted design guidelines. For bank repair and

protection projects, the Program emphasizes that biotechnical approaches will be used where possible, based on completion of hydraulic, geotechnical, and geomorphic analysis.

Using the above approach, nearly all work will include components to mitigate project impacts on-site. For additional mitigation, City/Zone 9 proposes to work with local nonprofit environmental groups to identify additional restoration/mitigation opportunities. City/Zone 9 will budget money each year for watershed and stream restoration programs. The amount of money contributed annually will be based on the external off-site mitigation needs of the program. In addition SLO/Zone9 will cooperate with local groups to obtain grant funding for stream corridor restoration and enhancement.

Most of the public lands along SLO Creek will be restored or enhanced as part of ongoing City/Zone 9 and/or Land Conservancy programs. The mitigation program (for the SMMP and a part of the Flood Management Plan element) recommends that some areas of SLO Creek managed by Caltrans as part of a "Channel Change" easement be turned over to either the County or a non-profit watershed management entity such as the Land Conservancy, for enhancement and management. This includes a large area of creek corridor extending downstream from the South Higuera Bridge to San Luis Bay Drive. Legal issues regarding this transfer will need to be explored prior to implementation.

On private lands, partnership with the Conservancy or another not-for-profit entity provides the best opportunity to conduct enhancement/restoration activities. However, the City and County will retain the right to develop mitigation plans independently of non-profits, as part of City or County sponsored programs. It is envisioned that most of this enhancement work will focus selectively on private lands in Reaches 3 to 6, (the unincorporated portion below Los Osos Valley Road to See Canyon), and in Reach 14, (above Cuesta Park). The lower reaches have bank erosion problems associated with natural adjustment to historic straightening (associated with construction of Highway 101), and a predominance of low diversity shrubby willows. The upper reaches have bank erosion problems from channel incision that are undermining old stream-side stands of native sycamores that are toppling into the creek. Protection of valuable shaded pools associated with undercut banks is the key management issue that mitigation will focus on here.

5.4 Bank Stabilization Program

The WMP includes a bank stabilization, erosion protection, and bank repair program using integrated (combining hard structures and vegetation) and soil bioengineering (also called biotechnical) approaches to minimize impacts. An integrated approach is intended to minimize wetlands fill and stream impacts, remove ongoing sediment contribution to the stream system, and provide riparian and aquatic habitat enhancement. This section of the WMP describes the bank stabilization, erosion protection, and bank repair techniques that are considered appropriate for use within the SLO Creek watershed.

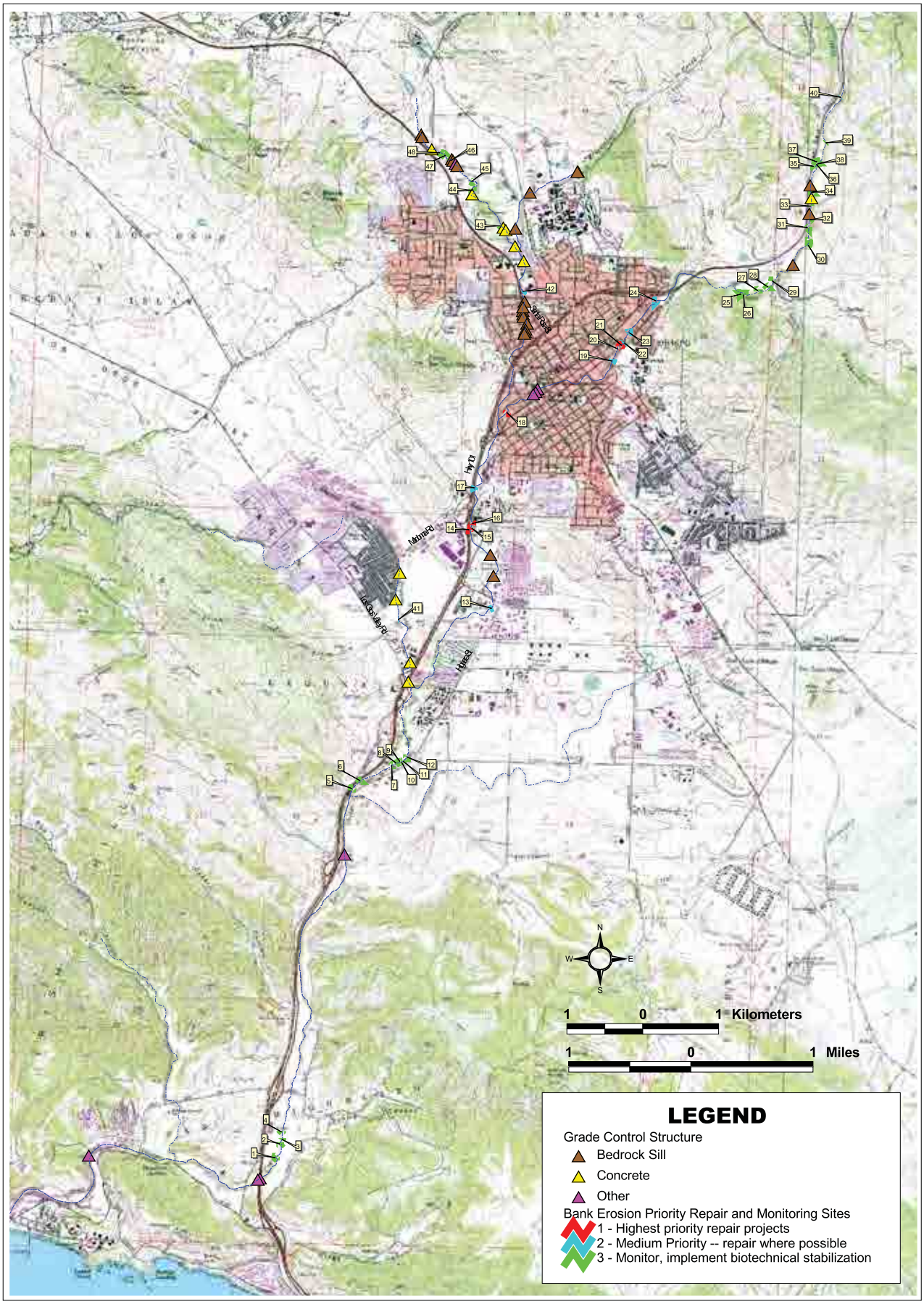
Bank stabilization techniques are outlined and presented at a conceptual level of detail**,** suitable for analysis in a general or Programmatic Environmental Impact analysis document, and as part

of a Individual Section 404 Wetlands Fill Permit application to the ACOE and other regulatory agencies.

Figure 5-15 shows the principal creeks of the SLO watershed indicating the location of the major bank instability problems as they occurred during the 1999-2000 field geomorphic inventory. The map also shows priority bank repair sites as identified during the creek inventory and analysis. This recorded failure problems at that point in time; other bank failures may develop in future years, particularly following extreme winters. Many problems occur in creek bends, or in reaches that were straightened and realigned (such as road and highway construction). Bank stability problems will likely continue at these locations. In addition, historic stream incision threatens a number of revetments within the City of SLO. These will eventually need to be repaired or replaced by individual property owners.

Table 5-3 summarizes each site, web site photo link, site description, and recommended bank stabilization or repair approach. There are three (3) repair recommendations for each site, in decreasing order of preference. The recommendations consider physical and biological conditions, and adjacent land use. Other solutions may be feasible. **Figures 5-16 to 5-19** illustrate the repair concepts. These were adapted from the U.S.D.A's National Engineering Handbook 16, *Streambank and Shoreline Protection (USDA-NRCS, 1996).*

Property owners who elect to implement one of the recommended bank stabilization techniques will need to conduct a detailed and site specific study to verify the design recommendation, and adapt it to their specific site conditions. A team of professionals retained by the property owner, (e.g. civil engineer, hydrologist, geomorphologist, geotechnical engineer, landscape architect, revegetation specialist, etc.) should prepare the detailed design. Consultation with a fisheries biologist or aquatic biologist is also recommended for most sites.



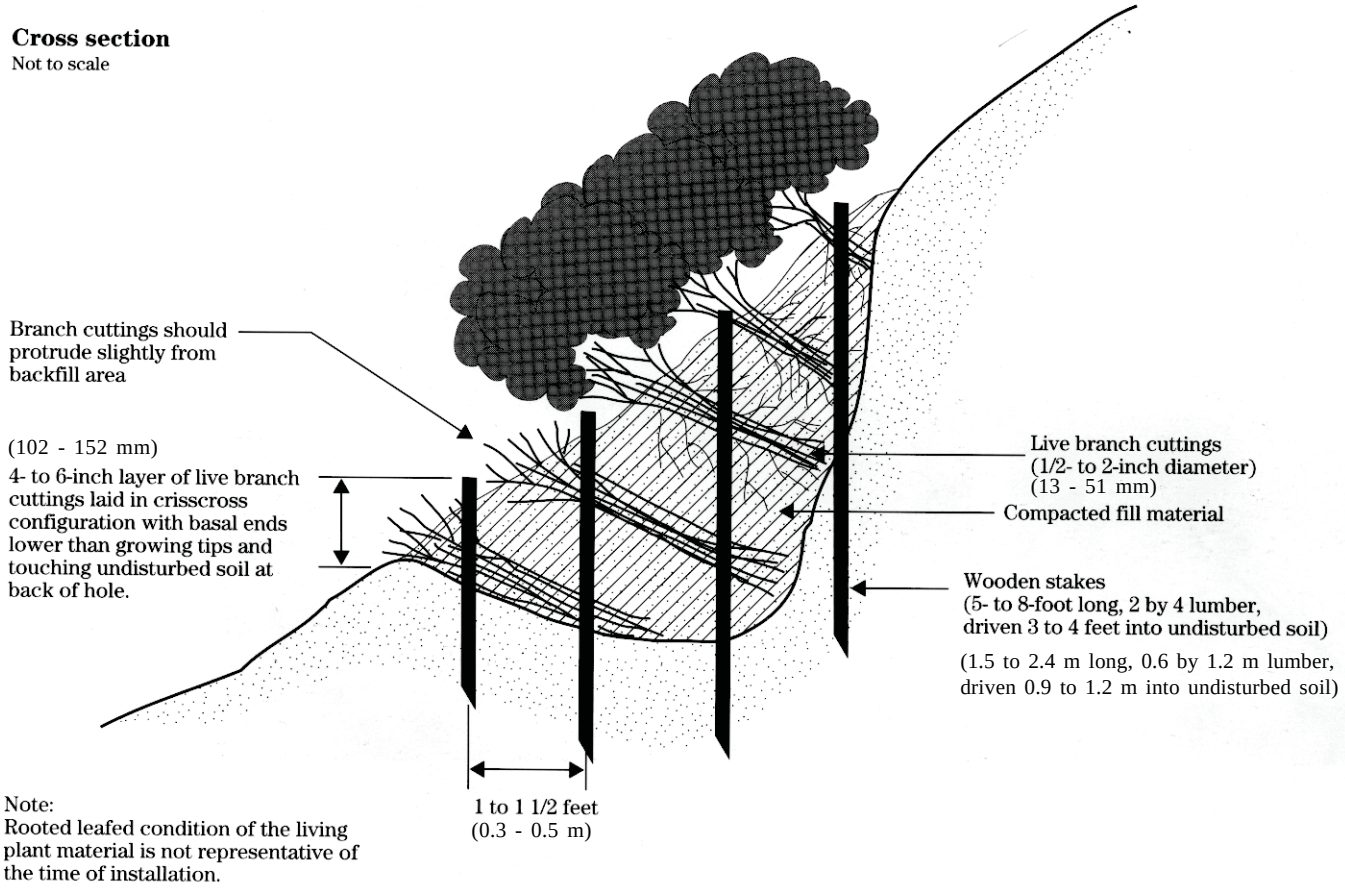
city of
san luis obispo

Bank Repair Program Sites

SLO Creek Phase II
Waterway Management Plan

QUESTA ENGINEERING CORPORATION

Figure
5-15



city of san luis obispo

PUBLIC WORKS DEPARTMENT 955 MORRO ST. 93401-3208

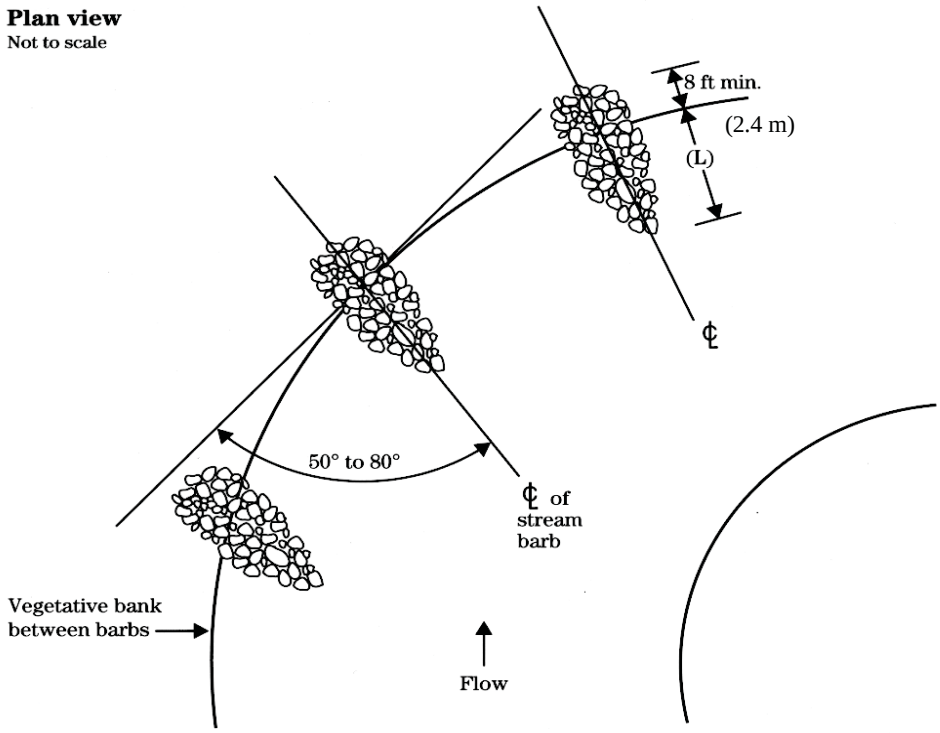
Brush Layering

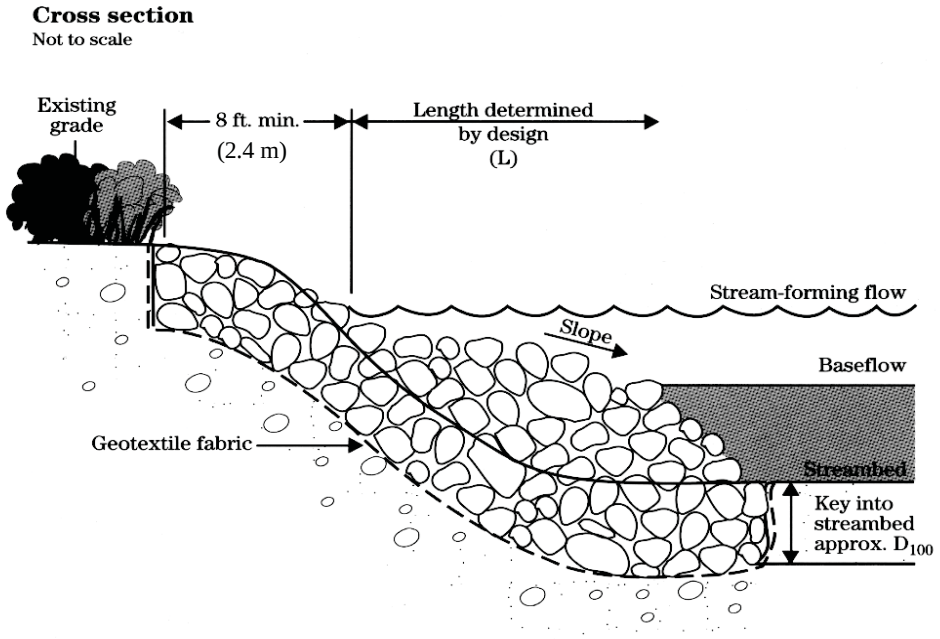
Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure

5-16





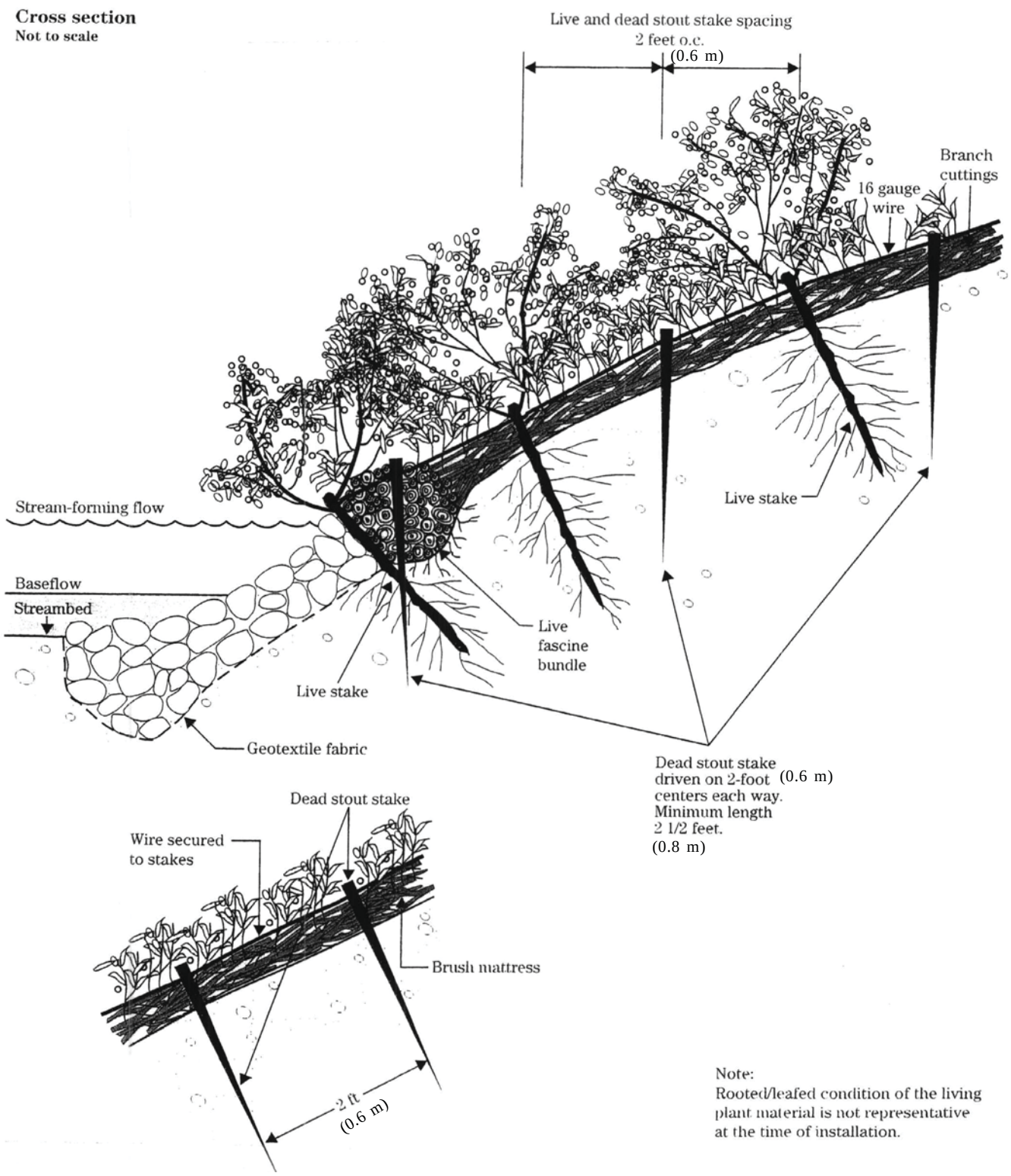
Flow Deflectors

Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure

5-17



City of San Luis Obispo
PUBLIC WORKS DEPARTMENT 955 MORRO ST. 93401-3208

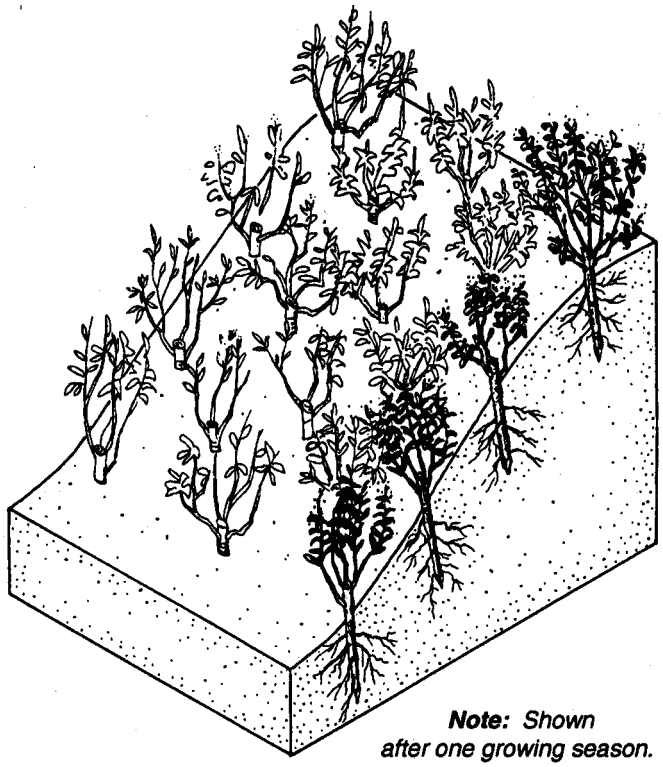
Brush Mattress

Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure
5-18

Live stake prior to installation



Note: *Shown after one growing season.*

Live Willow Staking

Waterway Management Plan
City & County of San Luis Obispo

QUESTA ENGINEERING CORPORATION

Figure

5-19

Table 5-3
Bank Repair Program Project Sites

Map Number	Creek Reach	Photo_path	Length (ft)	Priority Category*	Shear (lb/ft2)	Recommended Approach Method 1	Recommended Approach Method 2	Recommended Approach Method 3
1	3	hotlinks/40374.gif	44.4	3	60	Brush Layering	Flow Deflectors	Loose rock with willow staking
2	3	hotlinks/40369.gif	52.1	3	60	Brush Layering	Loose rock with willow staking	Fiber Rolls
3	3	hotlinks/40367.gif	32.9	3	60	Brush Layering	Loose rock with willow staking	Fiber Rolls
4	3	hotlinks/40364.gif	25.4	3	60	Brush Layering	Loose rock with willow staking	Fiber Rolls
5	7	hotlinks/32330.gif	36.6	3	200	Brush Layering with Rock toe	Live Willow Staking	Fiber Rock Rolls
6	7	hotlinks/32325.gif	42.2	3	200	Brush Layering with Rock toe	Live Willow Staking	Fiber Rock Rolls
7	7	hotlinks/32315.gif	22	3	100	Brush Layering	Live Willow Staking	Fiber Rolls
8	7	hotlinks/32313.gif	35.9	3	100	Brush Layering	Live Willow Staking	Fiber Rolls
9	7	hotlinks/32311.gif	40.9	3	100	Brush Layering	Live Willow Staking	Fiber Rolls
10	7	hotlinks/32310.gif	13	3	100	Brush Layering	Live Willow Staking	Fiber Rolls
11	7	hotlinks/32309.gif	14.6	3	100	Brush Layering	Live Willow Staking	Fiber Rolls
12	7	hotlinks/32308.gif	24.4	3	100	Brush Layering	Live Willow Staking	Fiber Rolls
14	9	hotlinks/40538.gif	23.1	1	250	Brush Layering	Planted Rock Rip-rap	Fiber Rock Rolls
15	9	hotlinks/40536.gif	31.7	1	250	Brush Layering with Rock Toe	Regrade Slope, Rock Toe, Erosion Fabric	Vegetated Geogrids
16	9	hotlinks/40533.gif	34	1	250	Brush Layering with Rock Toe	Regrade Slope, Rock Toe, Erosion Fabric	Vegetated Geogrids
17	10	hotlinks/40508.gif	64.5	2	100	Regrade Slope, Rock Toe, Erosion Fabric	Brush Layering	Vegetated Geogrids
18	11	hotlinks/30956.gif	26	1	275	Vegetated geogrids above Ajacks toe	Vegetated geogrids above rock toe	Fiber rock rolls
20	12	hotlinks/30763.gif	6	1	150	Vegetated Geogrids	Brush Layering with rock toe	
21	12	hotlinks/30761.gif	61.7	1	200	Loose rock with willow staking	Brush Layering with rock toe	Planted rock rip-rap
22	12	hotlinks/30760.gif	24.3	2	200	Flow Deflectors	Rock toe with willow staking	
24	13	hotlinks/30735.gif	36.2	2	220	Loose rock with willow staking	Rock toe, regrade bank	Planted Fiber Rolls
25	14	hotlinks/33131.gif	29.2	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking
28	14	hotlinks/33120.gif	42.3	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking
29	14	hotlinks/33115.gif	28.9	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking
32	14	hotlinks/33191.gif	37	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking
33	14	hotlinks/33184.gif	8.1	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking

Map Number	Creek Reach	Photo_path	Length (ft)	Priority Category*	Shear (lb/ft2)	Recommended Approach Method 1	Recommended Approach Method 2	Recommended Approach Method 3
35	14	hotlinks/30250.gif	39.7	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking
36	14	hotlinks/30249.gif	29.9	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking
37	14	hotlinks/30245.gif	59.6	3	0	Brush Layering	Planted Fiber Rolls	Loose rock with willow staking
40	14	hotlinks/30205.gif	3.7	2	0	Loose rock with willow staking	Ajacks	Fiber rock rolls
41	18	hotlinks/32226.gif	7.5	2	80	Drop Inlet w/ protected outfall	Planted Rock Rip-rap	Willow Wattling/Erosion Check
42	21	hotlinks/31668.gif	26	2	150	Loose Rock with Willow Staking	Fiber Rock Rolls	Ajacks
43	22	hotlinks/31625.gif	24.1	3	400	Loose rock with willow staking	Fiber rock rolls	Vegetated Geogrids
44	22	hotlinks/31601.gif	28.3	3	360	Brush Layering with rock toe	Flow Deflectors	Loose rock with willow staking
45	22	hotlinks/31576.gif	43.9	3	80	Brush Layering with rock toe	Loose rock with willow staking	Fiber rock rolls
46	22	hotlinks/31561.gif	49.2	3	280	Maintain existing willow stakes	Flow deflectors	Loose rock with willow staking
47	22	hotlinks/31555.gif	50.1	3	150	Planted rock rip-rap	Vegetated Geogrids	Loose rock with willow staking
48	22	hotlinks/31552.gif	67.3	3	150	Veg management (replace exotics w/ willows)	Fiber rolls/Erosion fabric	Loose rock with willow staking

* Priority Categories: 1) Highest Priority Repair Project 2) Medium Priority 3) Low Priority–monitoring recommended.

The design team must use the design approach and design procedures described in the companion document, *Drainage Design Manual for the City of San Luis Obispo, and portions of SLO County within the SLO Creek Watershed* (DDM). The DDM also outlines the required submittals and submittal format this document requires the design team:

1) To consider existing site geomorphic and hydraulic conditions in the design,
2) To consider potential downstream geomorphic consequences of the design,
3) To consider effects on flooding from stream encroachment or change in roughness values,
4) To select the softest approach to achieve a stable condition, and integrate native plantings into the design, to the maximum extent feasible.

Stabilization alternatives considered the physical conditions and biological constraints that occur within the stream reaches. The alternatives are at a conceptual level of detail, and the design will need to be adjusted to the actual horizontal and vertical dimensions of the bank failure problem. For some projects it may be necessary to mix and match elements of the alternatives presented (e.g. planted rock toe with coir erosion control blanket upper slope). It will also be important to transition the design upstream and downstream to stable sections of the creek, such as using planted rock, or sometimes with planted coir fiber rolls, or fiber rock rolls.

The proposed design will then be reviewed by the City or County, and if appropriate, and following revisions, included in the Annual Work Plan (AWP) submitted by the City or County to the ACOE as part of a Regional General Permit (RGP) agreement to be issued, associated with the SLO Creek Stream Maintenance and Management Program. The AWP would be submitted to regulatory agencies as part of a proposed Memorandum of Understanding (MOU).

All property owners will retain the right to submit their own proposed design and individual application to the regulatory agencies for separate consideration as an Individual permit, or for some small projects, a Nationwide Permit 13 (Bank Stabilization). However, the individual property owner will not be able to take advantage of the time and cost efficiencies, and permit streamlining created by the Programmatic CEQA document for the WMP, and any agency issued watershed-wide Individual Permit or MOU.

5.5 Habitat Restoration and Enhancement Program

5.5.1 Program Approach

Habitat enhancement opportunities and management needs were identified in **Section 3.** The WMP prioritizes sites that benefit from fisheries habitat enhancement and riparian restoration, such as removal of non-native plants, and native plant revegetation. Habitat Enhancement Projects would be completed as mitigation for impacts caused by structural flood control projects, bank repair and stream maintenance work, or as part of a strategy to better manage creek resources within the watershed.

For efficiency, and to make the best use of available funding, the Habitat Enhancement Program component will be integrated with work currently being completed by the City, County, Land Conservancy, and other agencies and nonprofit groups. For instance, the Enhancement Plan for the Filipponi property on lower East Fork of SLO Creek was a cooperative project recently implemented to resolve bank erosion, restore the historic riparian floodplain, and add pool forming structural stream habitat elements (root wads and boulders) to SLO Creek.

Portions of the ongoing enhancement work being completed by the Land Conversancy are being funded by the Unocal oil spill, Avila Beach, 1992 trust fund, with other sources of funding obtained from state and federal grants. Specific projects were identified in the *Final Plan for Restoration Actions within the San Luis Obispo Creek Watershed, Unocal Oil Spill, Avila Beach, 1992***,** prepared for the Avila Beach Trust Council by the Conservancy, and updated in 2002, as part of the *Land Conservancy Watershed Enhancement Plan.*

5.5.2 Fish Habitat Enhancement

Stream channels within the watershed are incised with many areas of steep eroding banks. The stream inventories completed as part of the Phase II studies and previous surveys completed by Cleveland (1996) noted a general lack of shaded pool habitat. Other deficiencies limiting steelhead populations include:

- Embedded spawning gravels
- Lack of canopy cover
- Elevated summer temperatures
- Deficiencies in the amount of in-stream structural elements providing cover, and
- Fish passage barriers

A program of adding in-stream structures in select channel reaches has been included as part of the WMP, based on the results of the creek inventories. The in-stream structures would consist of artificial cover structures such as lunkers, root wads, or rock weirs.

A rock vortex weir consists of boulders placed in a “V” pointing upstream, with gaps approximately the same size as the boulders, and with boulders in the center-the lowest in height. This boulder arrangement when designed, located, and placed sensitively, can create scour pools that remain viable during the summer, and can result in the deposition of gravels forming riffles at the pool tail. Other fish enhancement structures can consist of anchoring root wads onto the channel banks.

Barriers to fish migration were also mapped during the stream inventory work. One method to remove a barrier is to construct a boulder step-pool sequence. Step-pools consist of a series of boulder-formed pools across the width of the channel and downstream of the barrier that steps down in elevation in short drops. Typically the grade of the sequence of pools is 5-10% so some tall barriers may require a number of pools. The pools allow fish to rest and proceed in a series of jumps and movements. With this method, the barrier (often a dam) does not need to be removed completely and the channel grade upstream and downstream does not change. The

pools can be integrated with bank repair and revegetation projects without needing maintenance or removal of debris.

The City and County propose to contribute technical expertise and financial aid to the watershed program of the Land Conservancy and other nonprofits as a component of the overall WMP. Specific restoration and enhancement programs will be coordinated through the Zone 9 Advisory Committee and appropriate funding and projects selected each year. The City and County will also actively participate with nonprofit partners to request grant funding from state and federal programs.

5.5.3 Riparian Habitat Enhancement

The enhancement and biological inventory work completed for the WMP (see **Appendix B** of Volume I) identified needed riparian restoration, as well as areas where the control of invasive non-native plant species should be undertaken. This built on earlier work completed by the Conservancy and reported in *San Luis Obispo Creek Watershed Hydrologic Survey* (1996), and the recent Land Conservancy's *SLO Creek Watershed Enhancement Plan* (2002). Riparian habitat enhancement projects include:

- Expansion of riparian corridor width
- Closing the canopy by inter-planting in canopy gaps
- Expanding canopy or overstory species diversity, especially in willow monoculture areas by planting native trees such as sycamore, black walnut, and cottonwoods
- Increasing understory species diversity by planting native shrubs and groundcovers to provide wildlife habitat, food and cover
- Removal of exotic invasive species such as giant reed, and phased removal of large and hazardous trees such as eucalyptus and Monterey Cypress
- Providing wildlife movement corridors connecting fragmented habitat areas along waterways and uplands
- Bank Stabilization to protect large sycamores that are in danger of being undermined and toppling into the creek.

5. 6 Project Mitigation Requirements

The Stream Restoration and Enhancement Program can serve as a framework for mitigation of impacts associated with the SMMP and Flood Management and Bank Stabilization projects. Impacts cannot be fully quantified at this time, as they depend on specific project design details, and for bank stabilization and flood control projects, the construction schedule. However, based on the present conceptual plans, the range of impacts and estimates of mitigation needs are as follows:

- If all bank repair projects were completed over next 20 years (Individual Permit timeline), the amount of mitigation required would be about 550 meters (1800 lineal feet) of stream restoration and enhancement. This assumes that part of mitigation is included and internally mitigated in project design.

- Mitigation requirements for the Preferred Project flood management element totals approximately 2100 meters (7000 lineal ft.) of creek bank. Assuming a 5 meter (16 ft) and a 2:1 mitigation ratio with ½ of the mitigation completed onsite, this represents 10,500 m^2 (2.7 acres) of mitigation.

- Mitigation requirements for the bank repair and flood management aspects of the project will likely exceed 2600 lineal meters and well over 7.5 hectares (3 acres) of restoration and enhancement work. This exceeds the amount of publically owned land along the main stem of San Luis Obiso Creek in need of restoration and enhancement.

- As previously indicated, the sites west in need of enhancement and restoration are located in Reach 14, above Cuesta Park, and Reaches 3 to 6, betwee4n San Luis Bay Drive and LOVR, and in upper Prefumo Creek. Other potential candidate sites include lower Davenport Creek and Castro Canyon in the Irish Hills natural area. Phase I enhancement focused on Reach 7 between Prado Road and LOVR.

Restoration and enhancement would be coordinated with ongoing projects by the Conservancy and other nonprofits. Mitigation for structural flood control projects will likely need to be funded and implemented by the City and County.

5.7 Mitigation Bank

A wetlands mitigation bank is a wetland area (or stream zone) that has been restored, created, enhanced, or (in exceptional circumstances) preserved, which is then set aside to compensate for future conversions of wetlands for development activities. A mitigation bank may be created when a government agency, a corporation, or a nonprofit organization undertakes such activities under a formal agreement with a regulatory agency. The value of a bank is determined by quantifying the wetland values restored or created in terms of "credits." Project proponents that need to "mitigate" or compensate for authorized impacts to wetlands associated with development activities may have the option of purchasing credits from an approved mitigation bank rather than restoring or creating wetlands on or near the development site. Advantages of the use of Mitgation Banks are as follows:

- Banking can provide more cost effective mitigation and reduce uncertainty and delays for qualified projects, especially when the project is associated with a comprehensive planning effort.
- Successful mitigation can be ensured since the wetlands can be functional in advance of project impacts.
- Banking eliminates the temporal losses of wetland values that typically occur when mitigation is initiated during or after the development impacts occur.
- Consolidation of numerous small, isolated or fragmented mitigation projects into a single large parcel may have greater ecological benefit.

A mitigation bank can bring scientific and planning expertise and financial resources together, thereby increasing the likelihood of success in a way not practical for individual mitigation efforts.

Although the concept of the formation of a formal Mitigation Bank (limited to flood control and bank stabilization projects) was discussed at a Zone 9 Advisory Committee meeting, such a Mitigation Program is currently not a part of the Preferred Project.

5.8 Coordinated Resource Management Plan (CRMP)

The WMP *Preferred Project* recommends the formation of a formal Coordinated Resource Management Plan (CRMP). A CRMP consists of a joint Memorandum of Understanding (MOU) among local, state and federal agencies to review resource management and permitting issues, and prioritize and recommend funding of enhancement and restoration projects. A CRMP is sometimes utilized for grant funding, resolving conflicts, and other issues, such as those related to Endangered Species management approaches, and may be useful if a mitigation bank is developed.

6. FLOOD MANAGEMENT PLAN PROJECTS

A primary purpose of the overall watershed planning efforts is to develop environmentally sensitive and cost effective solutions to the recurrent flooding problems along SLO Creek and its tributaries. This section of the WMP presents conceptual flood management alternatives that address flooding problems throughout the watershed. Two somewhat contrasting alternatives for flood management were developed for public review and environmental analysis, and two other alternatives were also studied:

- **Preferred Project -** the environmentally superior alternative
- **Alternative 1** - has similar flood management objectives but a differing design approach
- **Alternative 2** – is a low cost/low impact alternative, but does not achieve the same level of flood protection as the preferred project and the competing design alternative.
- **Alternative 3** - includes a series of separate projects that were investigated but found to be infeasible and unaffordable because of potential disruption to the community during construction, significant environmental impacts, and/or high property acquisition and construction costs. These were dropped from further consideration early in the planning process.

The Preferred Project is summarized briefly here and in Section 6.1. The other alternatives considered are also summarized here and presented in more detail in **Appendix D**.

Summary of Preferred Project The Preferred Project includes both structural and non-structural flood control elements. Proposed structural elements include:

- Construction of a flood bypass channel and culvert replacement along SLO Creek below Los Osos Valley Road, and vegetation management in lower Prefumo Creek;
- Bypass channel construction in the Elks Lane area, upstream of Prado Road;
- Bypass channel construction and construction on an in-channel floodway terrace between Marsh Street Bridge and Madonna Road; and
- Enhancement of the detention effect caused by the Highway 101 culvert upstream of Cuesta Park.

  Replacement of Stenner Creek bridges.

Non-structural flood control elements include:

- New floodplain management regulations;
- Greater emphasis on, and City and County Engineering Department assistance in floodproofing; and,

- Implementation of a primarily voluntary program of targeted floodprone property acquisition, dependent on state and federal funding.

Alternative 1- Design Modifications to the Preferred Project Alternative 1 represents structural projects that would provide a similar or higher level of flood protection, compared to the Preferred Project, but channel environmental disturbance would be higher. Construction costs would generally be lower, because less land would be purchased for channel widening than the Preferred Project. This alternative evolved from discussions and review of the Preferred Project by the Zone 9 Advisory Committee. It represents an alternative that could be constructed with less overall costs than the Preferred Project, but with higher environmental impacts.

All of the main elements of the Preferred Project would be included in Alternative 1 (Stenner Creek Bridge replacement, Cuesta Park Detention Enhancement, channel maintenance in Mid-Higuera); however, several of the components have modified designs that may differ in their environmental impacts and in costs of construction, as compared to the Preferred Project. Modified design components include:

- Widen SLO/Prefumo Creek Confluence near Los Osos Valley Road, just below the confluence of Prefumo and San Luis Obispo Creeks, to prevent flow from backing up onto highway 101 and into Prefumo Creek on the west side of the Highway. The widened channel project (an in-channel bench or floodplain terrace beginning at OHW) would be constructed instead of the bypass channel of the Preferred Project.
- Channel Widening Between Cemetery above Elks Lane and WTTP below Prado Road. This would include replacement of the Preferred Project bypass channel with a channel-widening project from above Elks Lane downstream to Prado Road. The widened channel would be designed to provide 50-year protection for the adjacent mainly undeveloped floodplain and would prevent flow from spilling across Highway 101 and flooding the historic floodplain on the west side of the highway at the 50-year event. This would also consist of an in-channel bench or terrace constructed above OHW or the approximate 2-year flow level. A 100-year flood protection plan could also be constructed, with little additional environmental impacts, but would necessitate bridge replacement.
- Floodplain Excavation in Mid-Higuera Area. This would include a floodplain bypass channel excavation within the Mid-Higuera Business District, similar to the Preferred Project. However, the initial channel excavation work just below the Marsh Street Bridge would occur on the east bank downstream to just below the Bianchi Lane Bridge, and not on the west side at the Madonna Company construction yard.

The Cuesta Park Detention Enhancement Project and Stenner Creek Bridge replacement projects would be constructed as in the Preferred project.

Alternative 2 – Low Cost/Low Impact Alternative This represents a lower cost and modest impacts but achieves significantly lower levels of flood protection than the Preferred Project and Alternative 1 (the Design Alternative). Several of the individual project elements of this alternative are similar to the smaller components of the Preferred Project; but the more

extensive channel modifications and floodplain bypass channel excavation components have been eliminated. For the most part, the projects associated with Alternative 2 would be restricted to specific channel constrictions or breakout points along San Luis Obispo and Stenner Creeks. Alternative 2 includes the following:

- Minor channel excavation on the banks below the Marsh Street Bridge and a revised vegetation management program along the reach of San Luis Obispo Creek between Marsh Street and Madonna Road.
- Replacing three bridges on Stenner Creek, as in the Preferred Project.
- Improving flood detention storage on San Luis Obispo Creek above Cuesta Park, as in the Preferred Project.

Alternative 3 - Projects Not Considered Feasible and Not Evaluated Further In preparing the flood management section of the WMP, a large number of flood control concepts were initially evaluated as a "long-list" of possible flood management alternatives. A number of these were considered earlier in the 1977 Nolte studies, by the, or by Shaff and Wheeler in the late 1980's. Upon further analysis by the project study team, these were not considered feasible, either from a technical, cost, or environmental and permitting difficulty perspective. These conceptual projects were eliminated in developing the "short-list" of project alternatives and were recommended by the Zone 9 Advisory Committee to be placed in the category of "Not Considered Feasible, and Not Evaluated Further". They are described here to document for future reference purposes that these alternatives was considered in a preliminary fashion, and then discarded.

The projects, which were reviewed and determined to be infeasible, included:

- **Buried Bypass Culverts** - A buried bypass culvert around the downtown business district, running down Pacific Street or down Meadow Creek
- **Floodwalls** - Floodwalls along the east bank of San Luis Obispo Creek from Nipomo Street to Madonna Road.
- **Levees/floodwalls** along both creek banks above Prado Road combined with property acquisition of floodplain areas on the streamside of the floodwalls.
- **Small levees/berms** to prevent flow from spilling across Highway 101 between Madonna and Prado Roads.
- **Floodwall construction** near Andrews Street/San Luis Drive
- **Significant Channel Enlargement** between Marsh Street and Madonna Road to provide 50-year flood capacity
- **Flood Detention Basins** at Upper Stenner Creek and Upper SLO Creek above Reservoir Canyon Road.

6.1 Preferred Project Structural Flood Control

It is recognized at the outset that managing all of the flooding problems along SLO Creek to obtain a high level of flood protection, such as for a 100-year event, is not feasible for two reasons. First, environmental quality along most of the existing natural stream corridor would likely be adversely impacted by certain components of the project. Second, certain parts of these projects would be very costly, requiring right-of-way acquisition, extensive bridge, utility, and other infrastructure relocation, and complicated structural engineering. The structural solutions contained in the Preferred Project and the Viable Design Alternative do not provide 100 -year flood protection, but significantly reduce the frequency and depth of flooding and flood damage. Therefore a flood-proofing program for most reaches should be considered a complementary element. Flood control projects that are part of the Preferred Project are divided into structural solutions and non-structural solutions.

Table 6-1 summarizes the major project features of the City/Zone 9 Preferred Project. This important component of the WMP is based on:

1) Field inventory of creeks and GIS development
2) Hydrologic and hydraulic analysis
3) Problem Identification
4) Public Meetings (2) on inventory, problem identification and preliminary alternatives
5) Review and short-listing of "Long List" of alternatives by Zone 9 Advisory Committee
6) Engineering feasibility and benefit: cost analysis of "Short List" of alternatives
7) Designation of "Preferred Project" for CEQA/NEPA review purposes by SLO City Council
8) Development of "Other Alternatives Being Considered" for CEQA/NEPA review
9) Designation of non-feasible projects "Not Considered Further"

Table 6-1
Select Channel Modification Projects Land Requirements

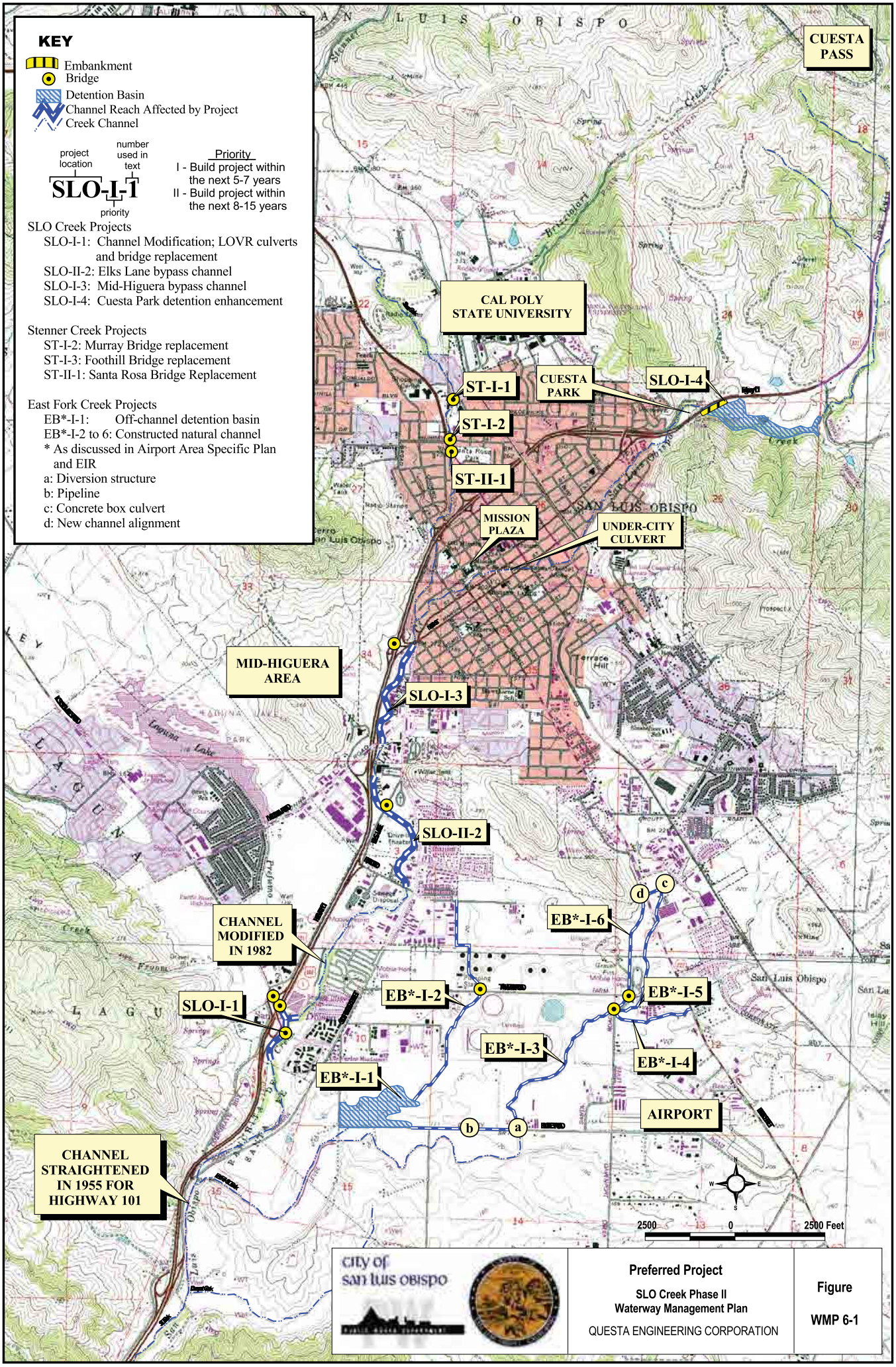
Project	Location	Design Flow	Major Project Features
SLO I-1	Channel Modification Below LOVR, LOVR Culvert and Bridge Replacement	100-year	• 400m (1300 ft) long by 45m (150 ft) wide bypass channel • Replacement of culverts where Prefumo Creek crosses Hwy 101 and the southbound off-ramp from Hwy 101 • Possible new bridge for bypass under LOVR
SLO II-2	Elks Lane Bypass Channel	50-year	• 1100m (3600 ft) long by 40m (130 ft) wide bypass channel • New bridge for bypass, adjacent to existing creek bridge on Elks Lane • 40m by 120 m-long terrace on west bank below Prado Road

Project	Location	Design Flow	Major Project Features
SLO II-3	Mid-Higuera Bypass Channel & Terrace	20-year	• 400m (1300 ft) long by 20 to 60m (65 to 200 ft) wide bypass channel
SLO I-4	Cuesta Park Detention Enhancement	Provides 100-year protection on SLO to Stenner Creek confluence	• Increases 100-year depth above culvert by about 3m (10 ft), and 10-year depth by about 2m (7 ft) • Increases drainage time for existing storage area from about 4 hours to approx. 8 hours at 100-year event • 5000-10,000m^2 embankment footprint
ST I-1 and ST I-2, ST II-3	Stenner Creek Bridge Replacements	100-year	• Replaces Foothill and Murray Street Bridges • Replaces Santa Rosa Street Bridge if further hydraulic studies indicate need.
EBI-1*	Buckley Road Detention Basin	Maintains current flow conditions on East Fork at SLO confluence	• 13.4 hectare (33 acre) detention basin
EBI-2 through 6*	East Fork Channel Modifications	100-year	• Constructed natural channel modifications along 8000m (25,000ft) of existing, mostly degraded channel.

* *For informational purposes only, project is part of Airport Area Specific Plan.*

The Zone 9 Advisory Committee, City, and County Engineering and Planning staff met monthly to review and provide input over an 18-month period. The structural elements of the Preferred Project are conceptual, and detailed environmental, engineering, cost estimating and financing studies must be completed before the concept plans proceed to final design, permit review, and construction. The Preferred Project provides a road map for how the SLO community intends to manage its flooding problems, and as such it can be used for forward planning and budgeting by the City and County. The Preferred Project is in draft form and changes to the concepts, including changed construction priorities, may occur as it proceeds through public review and agency comment.

Figure 6-1 references each of the Preferred Project flood management descriptions**,** with the map reference shown on the figure used in the text heading. The figure number also represents the proposed project prioritization. (Example, Project SLO I-1 is first project on SLO Creek, Priority 1). Individual projects are discussed below.


KEY
Embankment
Bridge
Detention Basin
Channel Reach Affected by Project
Creek Channel
project location
number used in text
SLO-I-1
priority
Priority
I - Build project within the next 5-7 years
II - Build project within the next 8-15 years
SLO Creek Projects
SLO-I-1: Channel Modification; LOVR culverts and bridge replacement
SLO-II-2: Elks Lane bypass channel
SLO-I-3: Mid-Higuera bypass channel
SLO-I-4: Cuesta Park detention enhancement
Stenner Creek Projects
ST-I-2: Murray Bridge replacement
ST-I-3: Foothill Bridge replacement
ST-II-1: Santa Rosa Bridge Replacement
East Fork Creek Projects
EB*-I-1: Off-channel detention basin
EB*-I-2 to 6: Constructed natural channel
* As discussed in Airport Area Specific Plan and EIR
a: Diversion structure
b: Pipeline
c: Concrete box culvert
d: New channel alignment
CUESTA PASS
CAL POLY STATE UNIVERSITY
CUESTA PARK
SLO-I-4
ST-I-1
ST-I-2
ST-II-1
MISSION PLAZA
UNDER-CITY CULVERT
MID-HIGUERA AREA
SLO-I-3
SLO-II-2
CHANNEL MODIFIED IN 1982
EB*-I-6
EB*-I-2
EB*-I-5
SLO-I-1
EB*-I-3
EB*-I-4
EB*-I-1
AIRPORT
CHANNEL STRAIGHTENED IN 1955 FOR HIGHWAY 101
2500 0 2500 Feet
city of san luis obispo
Preferred Project
SLO Creek Phase II
Waterway Management Plan
QUESTA ENGINEERING CORPORATION
Figure
WMP 6-1

6.1.1 Channel and Bridge/Culvert Replacement Work at Los Osos Valley Road (LOVR) (Project SLO I-1)

High water in San Luis Obispo Creek during storms as small as the 10-year event currently causes flooding of Highway 101 near Los Osos Valley Road (LOVR). This flooding extends up Prefumo Creek to Calle Joaquin. This proposed project would install a bypass channel to San Luis Obispo Creek near (below) LOVR to increase local capacity and reduce backwater flooding on Prefumo Creek and Highway 101 (**Figure 6-2**). The channel would be located on the east bank, and would extend downstream about 400 meters (1300 feet).

Prefumo Creek crosses under Highway 101 and the onramp to Highway 101 through two separate concrete box culvert structures. Replacing these culverts will be necessary to provide 100-year capacity in this area.

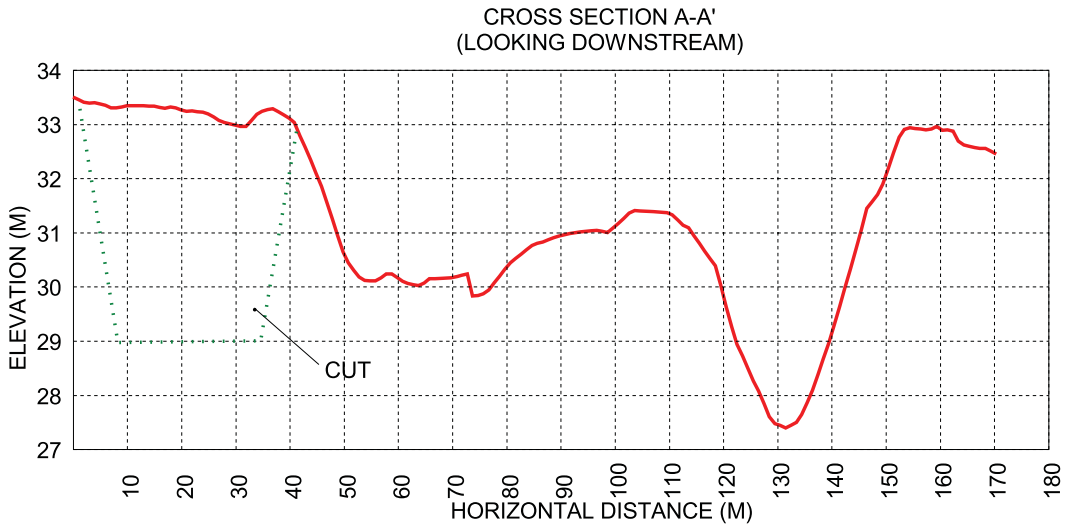
Currently, flow from San Luis Obispo Creek spills across Highway 101 during high flow events near Madonna and Prado Roads and eventually enters lower Prefumo Creek. The magnitude of the split flow is similar to the natural flow in Prefumo Creek. Installing culverts or a bridge with sufficient capacity to pass both the natural flow of Prefumo Creek and the added SLO Creek split flow would be difficult. This project assumes (for achieving 100-year protection) that the flow splits will be partially mitigated upstream by channel modifications or construction of a bypass channel parallel to SLO Creek in the Elks Lane area above Prado Road (see **SLO II 2**).

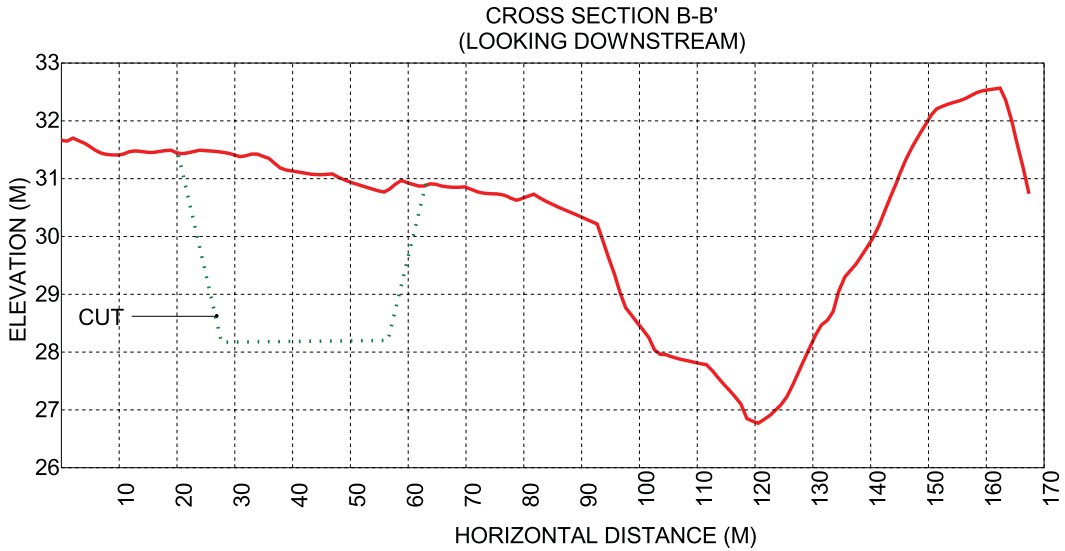
Additional lowering of the water surface elevations in lower Prefumo Creek would be achieved in this reach by managing the existing dense vegetation per the SMMP. This would involve selectively thinning and limbing up the willows, and inter-planting with single trunk species such as sycamores and cottonwoods. This work is also included as part of this project. Replacing the Prefumo Creek culverts under Highway 101 and the Highway 101 onramp are also included with this project, as is the construction of a bridge on Los Osos Valley Road across the proposed bypass channel (immediately east of the existing LOVR culverts crossing of SLO Creek).

6.1.2 Elks Lane Bypass Channel (Project SLO II 2)

Under existing conditions, at about the 20-year recurrence interval, flow spills out of the channel of San Luis Obispo Creek near Elks Lane (below the Lady Family Sutcliffe Cemetery) and flows overland across the floodplain, through the existing drive-in theater site, and eventually across Prado Road. The larger flood flows spill onto the City Corporation Yard and Waste Water Treatment Plant (WWTP) (Note: currently the sludge ponds and critical treatment facilities are not inundated by the 100-year flood). From there, larger flows spill across Highway 101 to enter lower Prefumo Creek while the rest returns to the main creek channel below the Wastewater Treatment Plant.

Flood protection to meet the proposed 50-year Design Flow for this area would be provided by creating a parallel bypass channel as shown in **Figure 6-3**. For most of its 1100-meter (3600 feet) length the 40-50 meter (130-165 feet) wide bypass channel would be separated





city of san luis obispo

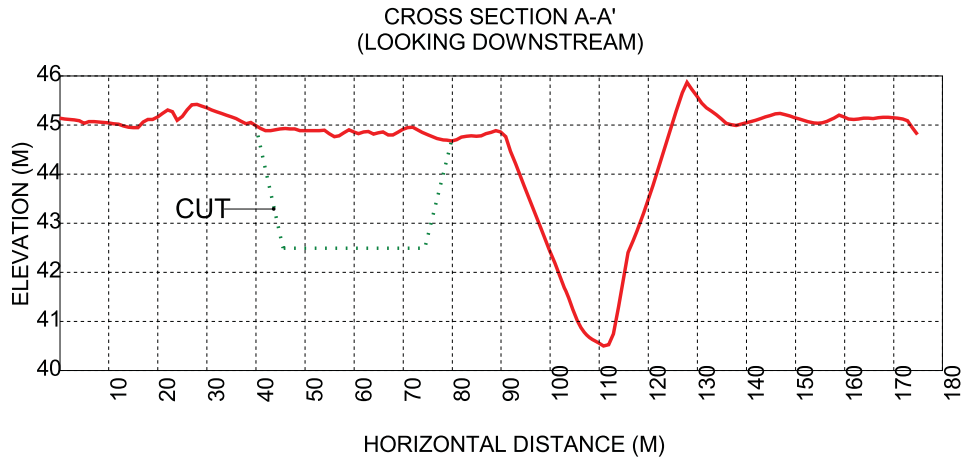
Channel / Bridge Replacement - LOVR

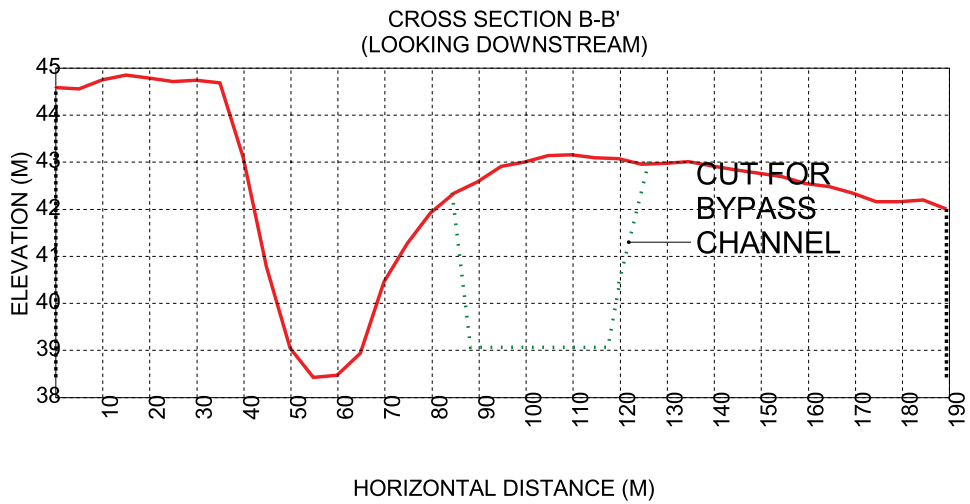
SLO Creek Phase II
Waterway Management Plan

QUESTA ENGINEERING CORPORATION

Figure

WMP 6-2





city of san luis obispo	**Elks Lane By-Pass** **SLO Creek Phase II** **Waterway Management Plan** QUESTA ENGINEERING CORPORATION	**Figure** **WMP 6-3**

from the existing channel by a variable width vegetated buffer at least 30 meters (100 feet) wide. Where the bypass crosses Elks Lane, a new bridge structure would be built.

Some channel modification work is also included with this project in the most constricted channel portion, adjacent to the Mausoleum below Madonna Road. There is not enough room here for a bypass channel or construction of an in-channel floodplain terrace, so a biotechnical retaining structure such as a live crib wall or vegetated geogrid is proposed for this approximately 70 meter (210 foot) section along the channel banks (west side). Even so, some continued flooding would occur in the cemetery area.

(Note: Further widening the bypass channel could contain the 100-year event flow with little additional impacts to SLO creek, but there may be little public benefit in this, considering the costs of the project. This widened bypass project, if constructed, may be the obligation of adjacent property owners and would be subject to additional environmental review, permitting and City Council approval. At another constricted location, just above Prado Road, it would also not be possible to provide 100-year protection without both widening the existing channel and replacing the existing bridge (assuming that portions of the WWTP cannot be relocated). The bridge currently passes the proposed 50-year Design Flow. The existing bridge at Elks lane would also require replacement for 100-year level of protection.)

At certain locations, it will be necessary to construct a levee or berm along low points on the west bank of the creek or bypass channel, especially near Elks Lane where the bypass will need to terminate and where flow currently leaves the stream channel. Any levees here would have minimal impact on upstream water surface elevations since the channel capacity would have been increased due to the channel modifications.

The downstream impacts of the project are more complicated, since flow that currently spreads out across the floodplain and spills across Highway 101 would be kept within the existing channel. It would be necessary to construct low levees or floodwalls on the east bank of the creek at certain locations near Prado Road, since the 100-year water surface elevation would be raised to near the top-of-bank at this location. Furthermore, the 100-year water surface elevation downstream of Prado Road could be elevated above the bank top at the existing mobile home park. This would be mitigated by constructing a low (1 meter or 3 foot) floodwall at this location.

By reducing the amount of floodplain available for storage, the hydraulic modeling shows that this project would result in less attenuation of the hydrograph (flood flow rate reduction) through the reach than currently occurs. The flood peak would travel through the reach more quickly than it currently does, reaching the confluence with the East Fork of SLO Creek about 10 minutes earlier than under existing conditions. Since under existing conditions, flow in the East Fork has already peaked by the time the flood wave on SLO Creek passes through, having the wave come through earlier could increase the total flow in the creek below Buckley Road. The increase in flow ranges from less than 1 percent above the confluence with the East Fork to between 2 and 3 percent below the confluence. There are no structures in this area that would be affected by the changed hydrograph and the effect is significantly dampened by the time peak flows reach the Avila Beach area.

Any flow that overtopped the stream banks in this reach would contribute directly to flooding of most of the “25-year protected” floodplain. The hydraulics of this flooding is

very complicated and is impossible to analyze without knowledge of the way development would occur in the protected area. It is likely that the flooding would occur in different areas than currently experience flooding. Since this scenario could occur relatively frequently (4 times in 100 years, on average), providing 25-year protection for this reach is not recommended without strict land use controls that ensure floodplain development will not greatly reduce the existing conveyance provided by the floodplain. These are provided for in the DDM *No Adverse Impact* and *No Net Fill* policies.

Any development plan for areas protected by this project needs to consider the impacts to flood conveyance through the floodplain. The DDM would also require that a Drainage Master Plan be developed for the area that ensures no increase in flooding because of the channel modification project and adjacent floodplain development.

6.1.3 Mid-Higuera Bypass Channel, Terrace and Vegetation Management (Project SLO I-3)

Over the past 40 years, there have been six significant flooding events between Marsh Street and Madonna Road. The last major flood event occurred on March 10-11, 1995. Historically, this reach has had some of the most frequent and significant flooding problems in the community. There are several reasons for the recurrent flooding problems***:***

- The channel has a smaller cross-sectional area and lower flood conveyance capacity than the channel immediately upstream and downstream. In addition, the channel grade flattens below Marsh Street.
- The floodplain has been significantly encroached upon by buildings and floodplain fill on Higuera Street.
- The Marsh Street Bridge, located at the upper end of the reach, historically becomes partially blocked by sediment and debris during high creek flow events, causing flow to spill out of the channel just upstream of the bridge. Flows travel down Higuera Street through the business area.
- During very large storm events, flow in SLO Creek can exceed the capacity of the large buried culvert under Higuera Street between Osos and Chorro Streets, with overflow from the break-out point traveling down Higuera, Marsh, and Pacific Streets, flooding the businesses before re-entering the channel at various return-flow points within the Mid-Higuera business district.

Previous studies (Nolte, 1977) identified several flood mitigation alternatives that are not considered economically justifiable or permissible by environmental regulatory agencies. Consequently, a project was developed within relatively strict design constraints that the project could not significantly modify the stream channel bed or remove major areas of native riparian vegetation.

In the Mid-Higuera area the channel work would consist of construction of a terrace along the creek located above the 2-year flow-line, and a bypass system constructed parallel to but mostly away from the existing creek alignment. The channel would be designed to carry an

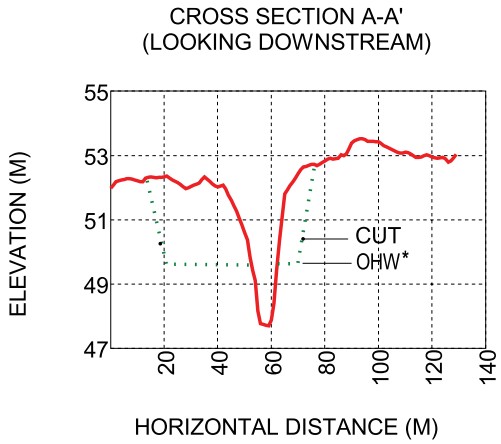
approximately 20- year storm (**Figure 6-4**). The excavation of the secondary overflow flood pathway on the floodplain would be on the west side of the creek. Where possible (and in most areas), the excavation of the flood secondary pathway would be isolated from the active channel by an island of higher ground ("untouched area") adjacent to the channel that supports native trees and shrubs. However, in several locations, including on the east bank at the Caltrans Maintenance yard, and on the west bank through much of Madonna Construction Company's yard, floodplain excavation would be contiguous to the creek. Excavation would begin above the 2-year flow line (above ordinary high water or ACOE jurisdiction), about 2 m (6.6 ft) above the channel bed. The floodplain would be lowered by 1.8 to 2.4 m (6 to 8 ft). All material would be hauled off-site and out of the 100-year floodplain.

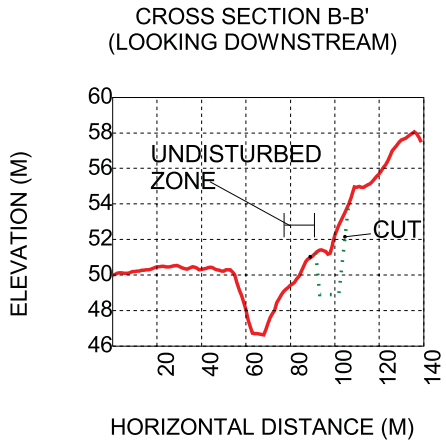
The reconfigured flood pathway would extend from the Marsh Street Bridge downstream to the Madonna Bridge, primarily on the west side of the channel. Approximately 400 meters (1300 feet) of creek length would be involved. The bypass channel would be built above the channel bottom of the existing channel, about 1/3 of the way up the bank, at the upstream and downstream transition points. These transitions would be protected with willow planted rock rip-rap.

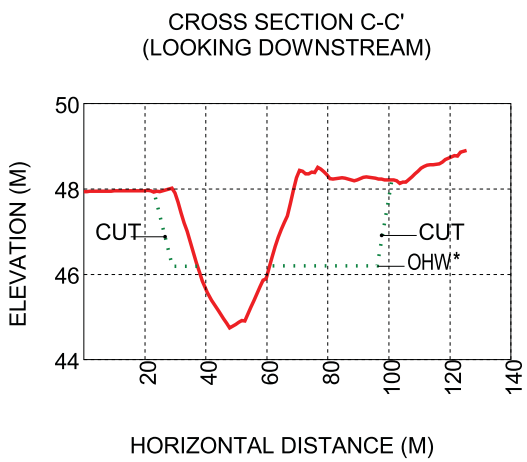
Only floodwaters in excess of a 2-year storm would move through the bypass channel. This would maintain summer low flow and prevent sedimentation in the pools in this area. The natural channel would remain to maintain in-stream fisheries habitat. The bypass channel would be planted with a scattered to semi-dense stand of native, wood-plant species. Periodic maintenance would be needed to remove low branches and other hydraulic roughness elements. The Bianchi Lane Bridge would be replaced with a clear span, arched structure as part of this project, if the property on the west side of the creek is to have all weather access.

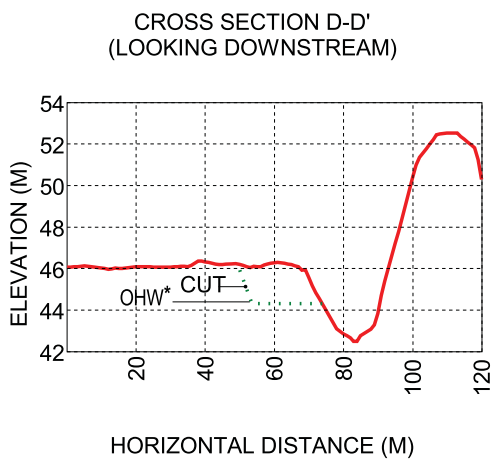
Marsh Street Property Floodway Terrace. This component of the Mid-Higuera project would entail excavation of a floodway terrace on the creek's east bank immediately downstream of Marsh Street Bridge (at the McNamara Real Estate property). In addition, minor improvements to the channel upstream of Marsh Street Bridge would be included to reduce the effects of sediment and debris blockage of the bridge barrels. Implementation of this element of the project would result in a predicted drop in water surface elevations of 0.28 m (0.9 ft) at the Marsh Street Bridge but has little direct impact elsewhere in the reach.

Channel Vegetation Management Program. An intensive, long term vegetation management program is included with the Mid-Higuera area project work. This constitutes measured, environmentally sensitive channel maintenance, reducing the channel roughness of the creek banks by carefully and selectively thinning and limbing up the willows, and inter-planting taller growing, single trunk native trees (Sycamores and cottonwood) on the upper creek banks. These would eventually shade out many shorter willows. In the short term, the lower branches on existing willows would be thinned during an annual maintenance visit, and any large gaps in the canopy would be inter-planted with tall, straight, tree forming species. Work would focus on willows along the lower channel banks, and phased replacement of









*Area below OHW to be protected and remain undisturbed.

city of san luis obispo	**Mid-Higuera Design Alternative** **SLO Phase II** **Waterway Management Plan** QUESTA ENGINEERING CORPORATION	**Figure** **6-4**

non-native trees, avoiding sensitive areas such as dense willow clusters adjacent to summer pools.

Each year the proposed channel maintenance work (City-wide) would be described in an Annual Work Plan (AWP) that will be provided to the ACOE and other regulatory agencies for review. A team consisting of a hydrologist and biologist would pre-mark in the field all sensitive areas, including trees to be preserved, hazard trees to be stabilized, trees to be thinned and limbed, and areas to be inter-planted with native trees and shrubs. A CDFG Biologist will be invited to review the proposed work, prior to implementation. The actual maintenance work will be supervised in the field by a qualified biologist.

The Mid-Higuera project would also include an intensive creek restoration effort involving both enhancement of channel conditions through the installation of in-stream structures (root wads, boulder clusters and lunkers as determined by a Fisheries Biologist), and revegetation of bank top areas.

Vegetation management would be completed in phases, and only become fully effective in 7-10 years or more. However, each year some important net reduction in channel flow resistance would be accomplished. Annual channel maintenance would be accomplished within the conditions of the overall SMMP.

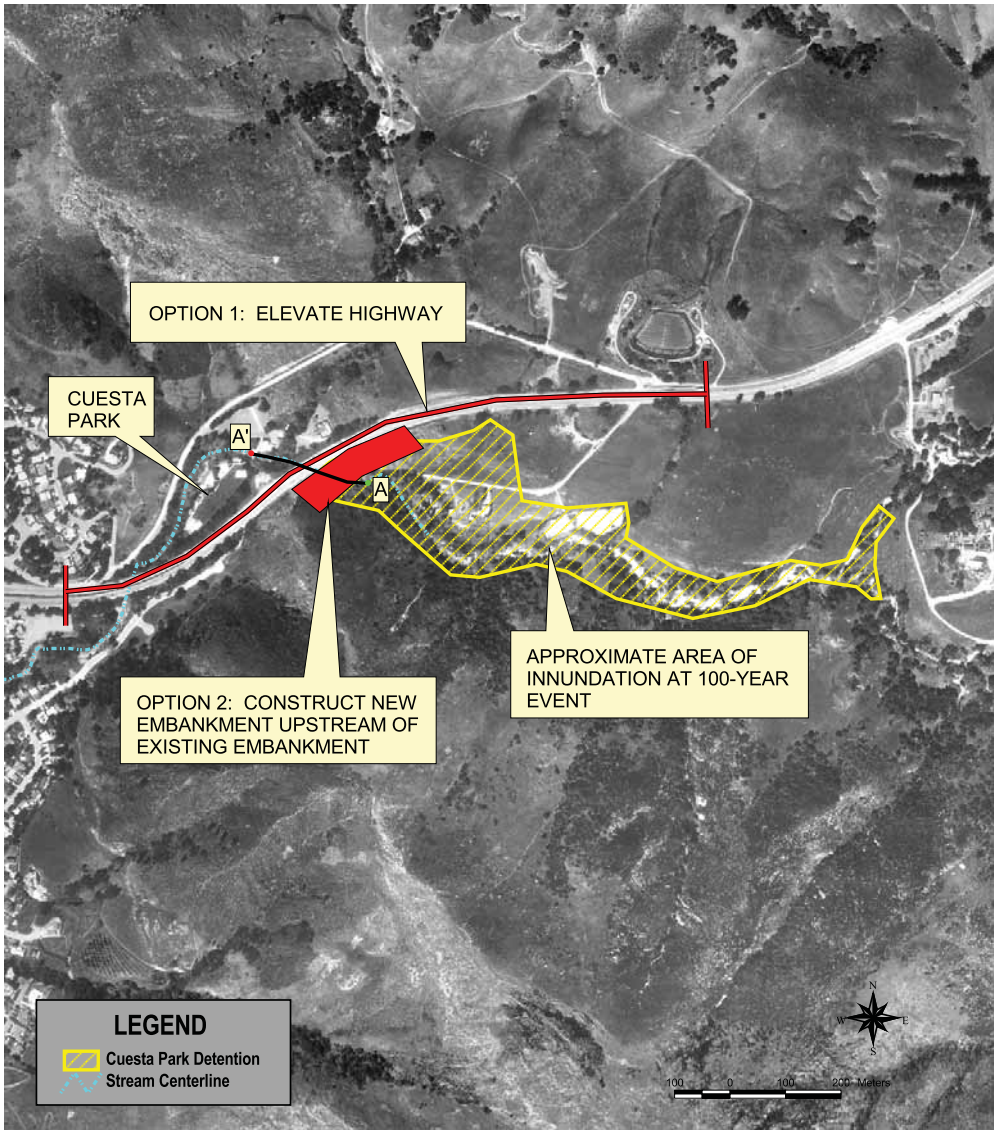
Vegetation management to achieve reductions in flood flow resistance must be completed carefully, balancing needed flood conveyance improvements with the risks of increased channel bed erosion from the resultant increases in channel velocity.

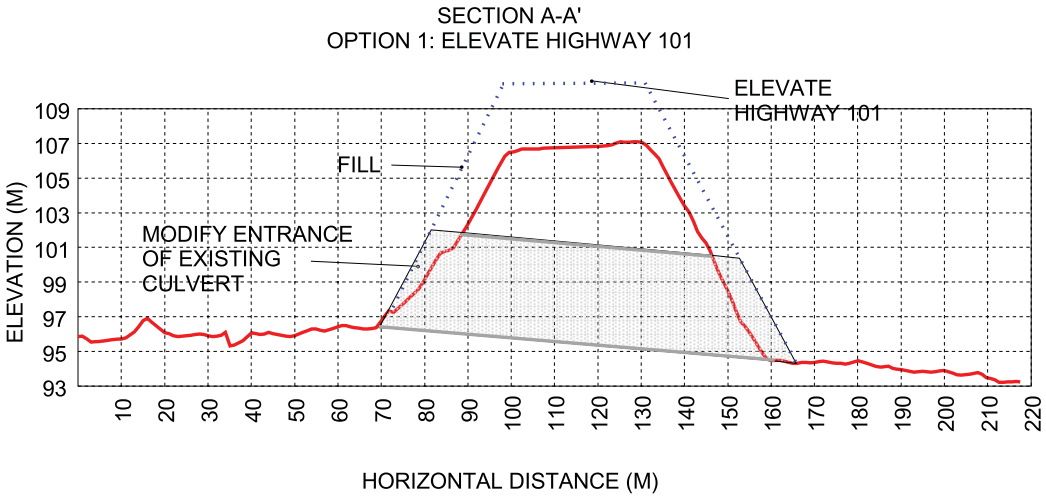
In some cases, channel bed and lower channel bank stabilization, (for instance using low 5 m or 18" rock channel grade stabilization structures, or planted rock rip rap) will be needed. The SMMP require that channel vegetation management field decisions be conducted by a team consisting of a hydrologist and biologist, and that the California Department of Fish & Game and National Marine Fisheries be invited to consult informally in the field on all such projects.

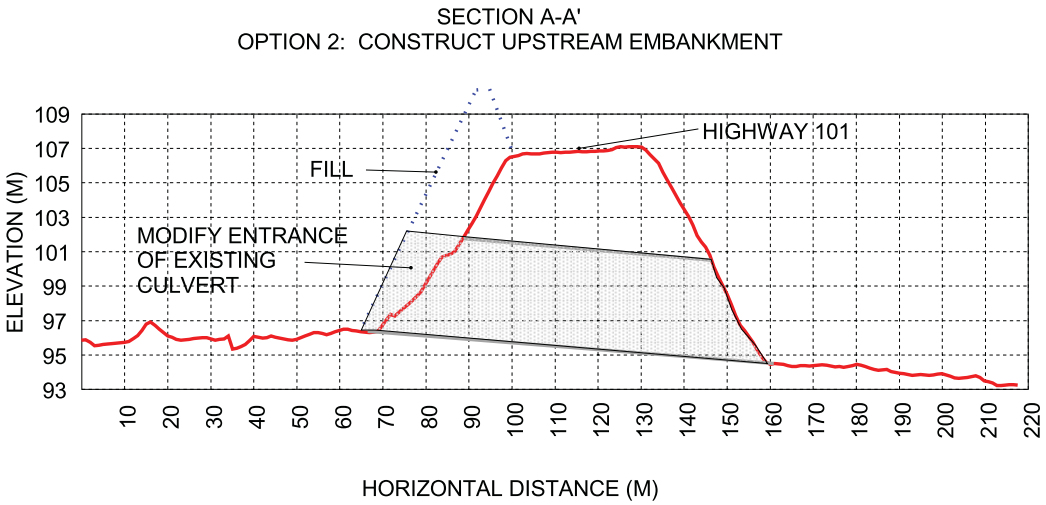
A program of active channel vegetation maintenance will have some benefit in this stream reach, reducing flood water surface elevations for the 10-year flood event by about 0.1 to 0.3 meters, (0.4 to 1.0 foot), depending on location within the reach.

6.1.4 Cuesta Park Detention Enhancement (Project SLO I-4)

Currently, the Highway 101 culvert crossing of San Luis Obispo Creek above Cuesta Park acts as a dam during very large storms, providing an important measure of flood protection storage for the City. This function would be enhanced by elevating the highway shoulder by about 5 meters (16 feet) and modifying the existing culvert (choking down the culvert to reduce flow and increase detention storage-see **Figure 6-5**). The upstream storage area would only fill (greater than it currently does) during rare events, and the flow detention would be temporary, lasting only several hours to at most a day. During most storms and most years, the upstream channel system would be essentially unaffected by the project.







city of san luis obispo	**Cuesta Park Detention Storage** **SLO Creek Phase II** **Waterway Management Plan** QUESTA ENGINEERING CORPORATION	**Figure** **6-5**

The structures proposed would be sufficient to reduce the 100-year flow rate within San Luis Obispo Creek through downtown San Luis Obispo to about 127 cms (4500 cfs), which is the reported capacity of the under city culvert (Nolte 1977). A slightly smaller structure (approximately 1-m lower) would be sufficient to provide 50-year protection. Also, if the capacity of the under-city culvert is determined to be higher than the reported 127 cms (4500 cfs), the embankment structure's size may be reduced. While the benefits of the project would potentially be quite large on San Luis Obispo Creek above the Stenner Creek confluence, they are not as significant below the confluence, (i.e. Mid-Higuera area) where the other projects are still required to address existing flooding problems. Since the culvert is owned by the California Department of Transportation, and embankment modifications would be within the Caltrans right-of-way, their authorization and cooperation is essential. The size of the detention structure will mean that the California Division of Dam Safety will need to be involved with project design review and approval. An emergency spillway will almost certainly be needed (there is not one for the existing structure). The design of the emergency spillway structure will make the project challenging, with potentially significant construction impacts on Highway 101.

The Cuesta Park project is a high priority. It will be one of the most beneficial in terms of flood reduction benefits with few environmental impacts. The conceptual plan needs to be further coordinated with Caltrans and the State Division of Dam Safety to address institutional feasibility issues.

6.1.5 Stenner Creek Bridge(s) Replacement (Projects S I-1, S I-2, SI I-3)

The Foothill, Murray, and Santa Rosa Street Bridges across Stenner Creek do not have sufficient capacity to pass the proposed Design Flows. Starting at between a 10-year and 25-year event, flow spills out of the channel, across Santa Rosa Street and through a residential neighborhood toward Chorro Street and Old Garden Creek. Replacing the three bridges would prevent this from occurring, removing the threat of flooding to a significant number of residences.

The proposed replacement of the Foothill Bridge is currently in environmental review and preliminary design. Since the Foothill and Murray Street bridges each cause flow to be lost from Stenner Creek, the replacement bridges must be designed and staged so that the no-longer detained flows do not move downstream and cause worse flooding at a downstream bridge (either Murray or Santa Rosa Streets). Installing temporary channel constrictors, or temporarily blocking portions of the structures until the downstream bridges are replaced can accomplish this.

The channel below Santa Rosa Street has an estimated 100-year flood conveyance capacity, so replacing all three bridges concurrently will not create increased downstream flooding risk. The Santa Rosa Street Bridge on Stenner Creek has undergone several stages of construction, which has resulted in an irregular bridge opening, making modeling the hydraulics of the Santa Rosa Street area quite difficult. Before a final decision is made to replace that bridge, a more detailed bridge hydraulic study and/or observation of

performance during high flow events are needed. However, it is unlikely that the Santa Rosa Street Bridge has 100-year capacity.

6.1.7 Detention Basin and Channel Work along East Fork - Airport Specific Plan (Projects EB I 1 to 6)

The WMP includes several drainage and flood control projects recommended in the Draft Airport Area Specific Plan, including a proposed regional storm water detention facility off Buckley Road, several bridge and culvert replacement projects, and modifications to the East Fork of SLO Creek and several of its tributaries. The Specific Plan-proposed East Fork modifications may not be entirely consistent with the DDM guidelines and the final design may have to be modified to reflect the DDM. A Constructed Natural Channel is required by the DDM. The drainage facilities shown in the Specific Plan have been included to provide the reader with a cumulative picture of the watershed-wide flood management facilities that may be built over the next ten years.

The recommended channel design would have a narrow in-channel vegetated terrace constructed at the 2-year flow line, with the upper banks sloped back 2.5:1 and revegetated with native trees and shrubs. A wide (100-foot minimum) buffer would be established along the bank tops on either side of the channel in most areas. The buffer area would be within the 100-year floodplain of the East Fork of SLO Creek and its tributaries. This corridor would also be planted with native trees and shrubs, although less densely than on the main branch of SLO Creek, reflective of the natural plant community throughout this area. A public access trail may be included within the buffer zone.

6.2 Preferred Project Non-Structural Flood Control

Non-structural measures in the Preferred Project include:

- Planning and Community Outreach
- Building Relocation/Demolition
- Flood Prone Property Land Acquisition

6.2.1 Planning and Community Outreach

There are three components to the proposed Planning and Community Outreach part of the Non-structural Flood Control Element: (1) Floodplain Management Policies; (2) Community Rating System, and (3) Flood proofing.

Floodplain Management Policies. The new and revised Policies contained in the DDM and discussed earlier are progressive and would comprise one of the strongest floodplain management programs in California. This is a major emphasis of the overall WMP flood management program.

Community Rating System. Educating residents that live in flood prone areas about the hazards of flooding and what they can do to be better prepared for the eventual flooding that will occur should be a major part of a flood management plan, and is a part of the WMP.

FEMA recognizes a number of community programs that involve educating residents in flood prone areas, a flood alert system, flood preparedness, as well as flood proofing in a program called "Community Rating System" or CRS. A community achieves points for each of several categories including those outlined above to get a total CRS score. Depending on the CRS score, the community falls into 1 of 10 categories, 1 being good, 10 poor. A low CRS score enables a reduction in federal Flood Insurance Program insurance premiums of up to 40%. Currently the City of SLO has a rating of 8, slightly below average for California cities, entitling City residents to a modest 5% insurance premium reduction. The WMP programs, including the planning and outreach efforts that went into the WMP will allow the City to improve its CRS rating by 1 or 3 points, and obtain an additional 5-15% reduction in premiums paid by private property owners. With annual premiums of about $250,000.00, this could save an aggregate $12,000-$30,000.00 to area residents annually living within the FEMA 100-year floodplain and participating in the federal Flood Insurance Program (FIP).

Flood Proofing. Flood proofing has several elements:

- Wet and dry flood proofing,
- Building elevation, and
- Purchase, relocation, and (occasionally) demolition of buildings in recurrent high hazard or high damage flood prone areas.

Wet and Dry Flood Proofing. Dry flood proofing involves protecting buildings with structures (such as concrete block walls) that completely prevents flood water entry, while wet flood proofing involves selection of flood resistant building materials, elevating utilities, and the use of other techniques to minimize damage to buildings and contents once flood waters enter. Flood proofing (wet and dry) has been used to some extent in SLO and is encouraged by the Community Development and Public Works Departments. The Land Conservancy had a voluntary flood-proofing program that provided matching funds in the early 1990's that had little participation.

City Building Regulations provide guidance on flood proofing based on FEMA standards. Flood proofing does not allow removal of property from the FEMA Flood Insurance Program (FIP). Although the WMP does not propose any major changes to current City flood proofing policies or programs, they really are the only element currently used by the City to minimize flooding. More emphasis will be placed on this area by providing additional technical assistance and advice to property owners. This will be achieved by planning and engineering staff comments and recommendations made on building renovation and remodeling applications submitted to the City or County for review and approval.

Building Elevation. Building elevation involves raising habitable portions of buildings above the 100-year flood level. Although this is not practical in many commercial areas that depend on walk-in business, it has applicability in some residential areas of the City. The Community Development and Public Works Departments currently considers Building Elevation as an important option to be considered on every property in a FEMA Flood

Zone "A" (100 – year floodplain) area. The City currently does not have a program to assist with building elevation but the City will explore a cost-sharing program to help qualified residents through grant programs afforded by FEMA and the California Department of Water Resources.

6.2.2 Building Relocation/Demolition

Building relocation is another common element of many non-structural flood control programs. Buildings in flood prone areas can be purchased and moved to areas outside the 100-year flood plain. A flood damaged home in the lower Stenner Creek area was purchased after the 1973 floods. This flood prone property is now the site of a community garden. In addition, as part of the building permit process for remodeling on a parcel within the FEMA 100-year floodplain, the City requires that they raise or flood proof, depending on the type of building.

Many residential buildings and mobile homes that are potential candidates for relocation represent affordable housing, a diminishing resource in the SLO community. Furthermore, there are not many sites available in the City for a large building relocation program.

Where it is not cost-effective to relocate the buildings, or where existing buildings create significant obstacles to implementation of the Flood Management Plan, the City may acquire the property and demolish the buildings. Although the City prefers a program of voluntary purchase at Fair Market Value, the City has authority if necessary to acquire the properties through condemnation proceedings, for the public good. Two properties with existing buildings will potentially need to be purchased and their buildings demolished to accomplish the objectives of the Mid-Higuera project (SLO-I-3), as currently designed. They are located immediately downstream of the Marsh Street Bridge on both banks, and currently occupied by McNamara Real Estate (eastside) and Madonna Construction (westside).

Building relocation is not practical for many of the commercial buildings in the Mid-Higuera area, given the general slab-on-grade method of construction of common commercial buildings in this area, and the high costs of moving. In addition, building relocation or demolition would need to extend all the way past Higuera Street, essentially destroying the Mid-Higuera commercial district. This is costly, and a drastic measure that would not be well accepted and was therefore not seriously considered. Nonetheless, some of the older housing including mobile homes in the Mid-Higuera area will be selectively targeted as part of a voluntary building relocation or demolition program, and several state and federal programs are available to help establish and cost share in such a program. The City will explore these. Overall, building relocation and demolition in areas of recurrent flooding is a minor but important part of the WMP.

Some houses on lower Stenner Creek could be targeted for voluntary moving, but considering the low recurrence interval of flooding in this area, (25-year return interval) and the generally low, nuisance type damages that occur from shallow flooding, a voluntary program may not attract many interested parties.

6.2.3 Flood Prone Property Land Acquisition

Floodplain acquisition (in this context) refers to the voluntary public purchase of undeveloped or vacant flood prone areas to prevent their development and further contribution to creek management problems. Usually some development potential and entitlement is implied that would cause increased flooding, loss of habitat, or bank instability. Alternatively, property purchase may make adjacent channel modification projects to achieve flood protection unnecessary, thereby avoiding creek impacts.

Several vacant parcels in the Elks Lane area are potential candidates for public purchase. Vacant parcels in the Mid-Higuera area may also qualify. This would be a very costly program. The purchases will only be made if the property owners agree and state or federal funding is obtained. The City is currently evaluating the need for property purchase (for building demolition and riparian restoration) on several parcels downstream of the Marsh Street Bridge in the Mid-Higuera area.

7. BENEFIT/COST ANALYSIS

7.1 Definition of Benefit/Cost Analysis

Benefit/cost analysis is a way of determining the relative worth of a capital improvement project for decision making as part of the public approval process. It attempts to quantify the economic costs of a project and compare them with the economic benefits likely to accrue to the community as a direct result of project construction. If benefits are greater than costs (i.e. the benefit/cost ratio is greater than one), the project is considered a net gain to the community and therefore worthwhile. If the costs of building the project exceed its likely economic benefits (i.e. the benefit/cost ratio is less than one), the community must decide whether the project has non-economically quantifiable benefits that justify its construction. If there are not over-arching non-economic benefits, a project with a negative Benefits relative to Costs probably is not worthwhile.

Although there is a lot of judgment that goes into any Benefit/Cost analysis, some worthwhile project benefits are intangible, and are difficult or nearly impossible to quantify accurately. The environmental benefits of stream habitat restoration and water quality improvements are examples. These were not factored into the Benefit/Cost Analysis, although the project designs have gone to great lengths to minimize impacts and the WMP includes programs for protecting and enhancing stream corridors. Benefit/costs analysis as completed by some Federal agencies have also been criticized because of the tendency to overstate commercial benefits, underestimate costs and not adequately address environmental benefits.

Nonetheless, there are several reasons to use benefit/cost analysis in evaluating the desirability of a set of flood management projects. First, it provides a way of determining whether a given project is worth doing from a purely economic standpoint. Second, Benefit/Cost analysis can help in prioritizing projects from a large list of possible alternatives, with the most beneficial probably worth doing first. Finally, a beneficial ratio is often a prerequisite for Federal funding for large capital improvement projects. For instance the ACOE uses a Benefit/Cost analysis procedure in decision making on all federally funded flood control and bank stabilization projects where they are involved.

7.2 Methodology

A Benefit/Cost Analysis requires the computation of two basic items: project costs and the economic benefits that the project is expected to provide. These two items must be comparable; in other words, if the project under consideration is likely to be built during the current year, but the benefits of the project are likely to be seen 25 or 50 years in the future, the economic value of the benefits must be discounted into present day dollars. For example, it would not be a good investment to spend $100,000 now to build a project that will result in a net benefit of $100,000 in 25 years. The money would be better utilized if put in a savings account to earn interest over that 25 years, and then withdrawn. This becomes even more complicated for a flood management project, since some small amount of the benefit might occur soon, say from preventing small nuisance floods every 5 to 10 years, while the more major benefits would likely occur later, for instance in preventing a very large and damaging flood many years in the

future. It is generally simplest to compute either an annual amount of damage prevented by the project or the net present worth of prevented damage, and compare that to the equivalent annual cost or net present worth cost, respectively, of the project.

Determining costs is generally the simpler part of a benefit/cost analysis, although cost estimation can be challenging for projects designed at a conceptual level. A Unit Cost Summary for constructing and maintaining the projects under consideration in the WMP is in **Table 7-1.**

Computing the economic benefits of the proposed projects is somewhat more complicated than computing costs. The economic benefits that a flood management project will provide to a community are generally considered to be the amount of flood damage and lost economic activity that the given project is likely to prevent. Consequently, the accuracy of the analysis depends on accurately defining flood risk; both before and after a flood management project is in place. The determination of benefits thus involves defining flood hazard risk and then estimating the damages this risk is likely to cause, and then comparing this to the flood risk (and thus damage risk) likely after a given flood management project is built. Damage is assumed to be directly related to flooding depth.

The WMP has defined a set of watershed hydrology and hydraulic models that together predict floodwater depth throughout the SLO Creek and tributary floodplains. The models predict flooding depths for storms with a 10 percent (10-year), 4 percent (25-year), 2 percent (50-year), and 1 percent (100-year) chance, respectively, of occurring in any given year. To convert this flood risk to economic damage risk, flooding depth near the entrance to each building in the floodplain (as identified on the City's 2000 digital orthophotographs) was computed using a Geographic Information System. A curve developed by the Federal Emergency Management Agency (FEMA, 1995), as shown in **Table 7-2**, was used to determine the damage likely to be caused to each building for the computed depth of water, as a percentage of total building value. Building value was computed based on the appraised value of buildings according to tax records for commercial buildings and was assumed to be $241,523 per property for residential buildings, based on typical real estate transactions for residential buildings in the year 2000 (Carter, pers. comm, 2001).

Several types of damage that would probably be associated with a large flood were not specifically accounted for in the analysis. These include:

- Loss of income for businesses during storm cleanup,
- Damage to building contents,
- Costs associated with homeowners finding temporary housing,
- Increased maintenance costs for the city,
- Difficult to quantify costs such as decreased emergency access to certain parts of the city during and after the flood, and
- Lost development opportunity on floodplain lands that are not developable because of their flood risk (these lands of course provide benefits to adjacent and downstream floodplain land by providing some flood attenuation, and provide useful open space to the city).

With damage computed for each storm probability level, a damage probability distribution function was developed by multiplying the probability of damage by the damage computed for that probability level. The area under this curve represents the long-term equivalent annual flood damage. This procedure was repeated for each different flood management project, so that an equivalent annual damage could be computed for each project. The difference between the equivalent annual damage for existing conditions and the equivalent annual damage after the project represents the project's equivalent annual benefit. This was converted to a net present worth so that a benefit/cost ratio could be computed. Costs were computed in present worth rather than annual cost.

Table 7-1
Unit Cost Summary

Item	Unit Cost	Unit
Clear and Grub	$2.00 to 8.00	m^2
Bridge construction	$2000.00	m^2 bridge deck area
Pavement Repair	$35	m^2
Property Acquisition (undeveloped land within city limits)	$100,000	ac
Property Acquisition (developed land)	$300,000	ac
Import select backfill	10	m^3
Earthwork: Excavation/Hauling	12	m^3
Earthwork: Backfill/Compaction	3	m^3
Earthwork: Spoils Disposal	5	m^3
Revegetation	2.50	m^2
Bridge Demolition	$50,000	each
Building Demolition	$50,000	each
Building Relocation	$150,000	each
Floodwalls	project specific	
Concrete Channels and Culverts	project specific	
Relocate Utilities	project specific	
Bank Stabilization	$500	m
Miscellaneous Structures	project specific	

Table 7-2

Flood Insurance Administration (FIA) Depth-Building Damage Data

Flood Depth	Building Damage Percent by Building Type (based upon replacement value)					
	1 Story without Basement	2 Story without Basement	Split Level Without Basement	1 or 2 Story with Basement	Split Level With Basement	Mobile Home
-2	0	0	0	40	3	0
-1	0	0	0	8	5	0
0	9	5	3	11	6	8
2	22	13	13	20	16	63
3	27	18	25	23	22	73
4	26	20	27	28	27	78
5	30	22	28	33	32	80
6	40	24	33	38	35	81
7	43	26	34	44	36	82
8	44	26	41	49	44	82
9	45	33	43	51	48	82
10	46	38	45	53	50	82
11	47	38	46	55	52	82
12	48	38	46	55	52	82
13	49	38	47	59	56	82
14	50	38	47	60	58	82
15	50	38	47	60	58	82
16	50	38	47	60	58	82
17	50	38	47	60	58	82
18	50	38	47	60	58	82

*FIA: Depth-Damage Data Table-*Units in Feet of Flood Depth.*

Source: FEMA, 1995

Both costs and benefits are affected by the period of analysis and the interest rate assumed to apply over that period. Interest rates for this analysis were taken from the White House Office of Management and Budget (OMB). A high interest rate tends to make large capital improvement projects appear less beneficial than a low rate does, because at a high rate, the money invested in the project would return more if not spent than it would if the rate were low. Another way of looking at this is that a property owner at risk of flooding who wanted simply to provide self insurance against likely flood damage would have to put less money aside every month with a high interest rate, because the money saved would grow faster than at low rate. In other words, damages likely to occur in the future are less costly in terms of present dollars with

a high interest rate than with a low one. The OMB interest rate used in this analysis is 3.2% (taken as of April, 2001, when the analysis was performed). This compares with a rate of 5.875% used by Nolte, 1977, and 7%, which was the OMB rate in 1994. The useful life of all projects for this analysis was assumed to be 100 years.

7.3 Results

With both costs and benefits computed, it is a simple matter to compute a benefit/cost ratio by dividing the net present worth of the benefits by the net present worth of the costs. Assuming each project will have a 100-year useful life, and assuming a discount (or interest) rate of 3.2%, as published by the Federal Government for capital improvement projects, the net present worth value for these projects is shown in **Table 7-3**.

The Mid-Higuera and Cuesta Park Detention projects are beneficial or nearly so. The 100-year flood control Bypass channel and culvert replacement projects at Los Osos Valley Road and the proposed channel modifications at Elks Lane (the 50-year Design Flow By-Pass Channel) are not. These latter projects primarily protect undeveloped floodplain land, which was assigned no significant value in the benefits portion of this analysis. When channel modifications are completed to a 100-year design level, these projects do provide additional benefits by preventing floodwater from spilling across Highway 101. However, these benefits are not great enough to result in a beneficial project because most of the land on the west side of Highway 101 that is protected is currently undeveloped and is not assigned a significant public value in this analysis. They do provide private benefits to adjacent properties. Both projects however, provide significant improvements to traffic flow and safety during flood emergencies in the City, as well as along Highway 101, by avoiding highway closure, and preventing potential isolation of the City's Emergency Management facilities at the Corporation Yard near the Sewage Treatment Plant. It should be noted that there was one death in 1995 at the LOVR off ramp as a direct result of flooding.

If one assumes that the flood prone properties that would be removed from the floodplain have increased commercial real estate value, then the projects would no doubt have favorable Benefit/Cost ratios. However, these benefits would not accrue to the public, indicating a large portion of the costs should be borne by the principal beneficiaries, the property owners adjacent to SLO Creek, or those that would benefit the most.

Tables 7-4 through **7-8** identify estimated individual project costs.

Table 7-3
Benefit/Cost Summary

Project	Location	Costs Considered in Analysis			Computed Benefits[1]		Benefits Divided by Costs
		Initial	Annual	Total Present Worth	Annual	Present Worth	
SLO-1	Channel Modification Below LOVR, LOVR Culvert And Bridge Replacement (100 yr.)	**5,025,700[2]**	**0**	**5,025,700**	**16,200**	**486,000**	**0.09**
SLO-2	Elks Lane Bypass Channel (50 year)	**9,455,300**	**0**	**9,455,300**	**41,800**	**1,250,000**	**0.13**
SLO-3	Mid-Higuera Bypass Channel (25 year)	**3,836,550**	**26,000**	**4,805,000**	**154,800**	**4,629,000**	**0.96**
SLO-4	Cuesta Park Detention	**7,967,750**	**0**	**7,967,750**	**390,300**	**11,675,000**	**1.46**
ST-1, 2, and 3	Stenner Creek Bridges Replacement[3]	**1,990,925**	**0**	**1,990,925**	**46,400**	**1,387,000**	**0.20**

1 Assumes a 100-year project life and a discount rate of 3.2 percent
2 Does not include costs for replacing culvert under Highway 101
3 Assumes Santa Rosa Street does not require replacement.

Table 7-4

SLO-1: Los Osos Valley Road
Prefumo/SLO Confluence Improvements (100-year level of protection)

Item No.	Description	Est. Qty.	Unit	Unit Price	Total
1	Property Acquisition (undeveloped land)	5	ac	100,000	500,000
2	Clear and Grub	20,000	m^2	2	40,000
3	Earthwork:: Excavation and Hauling	33,000	m^3	12	396,000
4	Earthwork:: Spoils Disposal	33,000	m^3	5	165,000
5	New Bridge across Bypass, Los Osos Valley Road	400	m^2	2,000	800,000
6	Replace Hwy 101 Culvert Xing of Prefumo Creek	600	m^2	2,000	1,200,000
7	Replace Hwy 101 Onramp Culvert Xing of Pref.	120	m^2	2,000	240,000
8	Bank Stabilization/Revegetation	250	m	500	125,000
				Subtotal	3,466,000
				Engineering and Administration 25%	866,500
				Contingency 20%	693,200
				Total	5,025,700

Table 7-5

SLO-2. Elks Lane Bypass Channel

Item No.	Description	Est. Qty.	Unit	Unit Price	Total
1	Earthwork (includes excavation and spoils disposal)	160,000	m^3	17	2,720,000
2	Clearing and Grubbing. Erosion control.	45,000	m^2	4	180,000
4	New Bypass Bridge at Elks Lane	250	m^2	2,000	500,000
5	Levees/Floodwalls below Prado Road	350	m	400	140,000
6	Temporary Traffic Control	1	job	50,000	50,000
7	0.15 m thick Concrete Channel Lining at Mausoleum (assume $400/m3 concrete)	5,000	m^2	60.00	300,000
8	Live Crib Wall at Mausoleum	120	m	1200.00	144,000
8	Revegetation & Restoration	45,000	m^2	4.00	580,000
9	Property Acquisition - (Developed Parcels)	3	ac	400,000	1,200,000
10	Property Acquisition - Undeveloped banktop land	7	ac	100,000	700,000
				Subtotal	6,514,000
				Engineering, Permitting, and Administration 25%	1,628,500
				Contingency 20%	1,302,800
				Total	9,445,300

Note: This assumes that property will be acquired essentially only along the project footprint. It does not assume that additional area will be acquired where the project makes an entire parcel unusable.

Table 7-6

SLO-3: Mid Higuera Bypass Channel

Item No.	Description	Est. Qty.	Unit	Unit Price	Total
1	Earthwork: Excavation and Hauling	42,500	m^3	12	510,000
2	Earthwork: Spoils Disposal	42,500	m^3	5	212,500
3	Property Acquisition (developed land)	3.5	ac	250,000	875,000
4	Clear and Grub	30,000	m^2	8	240,000
5	Channel, Bank Stabilization/Restoration	800	m	500	400,000
6	Replace Bianchi Lane Bridge	100	m^2	2,000.00	200,000
7	Revegetation/Vegetative Management	30,000	m^2	4.00	120,000
				Subtotal	2,557,750
				Engineering, Permitting, and Administration 25%	639,375
				Contingency 20%	639,425
				Total	3,836,550

Table 7-7

SLO-4. Cuesta Park Detention Enhancement

Item No.	Description	Est. Qty.	Unit	Unit Price	Total
1	Engineering Study of Geotechnical Stability & Embankment & Spillway Design	1	job	allow	400,000
2	Import Select Backfill	80,000	m^3	10	800,000
3	Earthwork (Hauling and compaction of berm)	80,000	m^3	15	1,200,000
4	Clearing and Grubbing	10,000	m^2	8	80,000
5	Pavement Demolition & Repave Highway	16,000	m^2	35	560,000
6	Repave Highway	16,000	m^3	40	640,000
7	Emergency Overflow Structure (3' thick gabions)	1	job	allow	300,000
8	Culvert Modification	1	job	allow	100,000
9	Temporary Traffic Control	1	job	allow	75,000
10	Developed Property Acquisition	1	parcel	700,000	700,000
11	Open Space Property Acquisition in Impoundment Footprint	32	ac	20,000	640,000
				Subtotal	5,495,000
				Engineering and Administration 25%	1,373,750
				Contingency 20%	1,099,000
				Total	7,967,750

Note: This assumes that property will be acquired anywhere along the area inundated at the 100-year event. It does not allow for any existing easement which might existing along the creek. In addition, it does not assume that additional area will be acquired where the project makes an entire parcel unuseable/unbuildable (which is not likely the case here anyway).

Table 7-8

Stenner-1, 2 and 3: Stenner Creek Bridge Improvements

Item No.	Description	Est. Qty.	Unit	Unit Price	Total
1	Demolition	2	Bridges	50,000	150,000
2	Replace Foothill Boulevard Culverts	1	job	750,000	750,000
3	Replace Murray Street Bridge	180	m^2	2,000	360,000
4	Pavement Repair	1,800	m	35	63,000
5	Relocate Utilities	1	job	50,000	50,000
				Subtotal	1,373,000
				Engineering and Administration 25%	343,325
				Contingency 20%	274,600
				Total	1,990,925

Note: Foothill Boulevard Culverts do not need to be replaced to provide 25-year protection. This would save approximately $375,000 from the total price reported in the above table. Structure is being replaced due to structural failure.

8. IMPLEMENTATION AND FINANCING

8.1 Project Schedule and Build-Out Assumptions

The WMP *Preferred Project* presents recommended flood control, bank stabilization, and habitat enhancement projects at a conceptual level. As such, the WMP is intended to be a road map for future City and County action with multi-year implementation. The first step will be project approval by the City, County, and various state and federal regulatory agencies. Implementation will occur over the next two to ten years (or more), depending on funding. The WMP sets priorities and identifies needed expenditures for future Capital Improvement Projects (CIP) such as bridge replacement and channel modification. It is expected that the majority of these CIP will be subject to additional CEQA/NEPA review, public hearings, and SLO County Board of Supervisors and City Council approval as the projects move forward in the design and budgeting process. Nearly all of these projects will also be subject to additional environmental review and permitting at the state and federal level as detailed plans are developed and construction is proposed.

The policies and procedures contained in the Drainage Design Manual and the Stream Maintenance and Management Program will become effective upon the adoption of this document and the associated EIR/EIS by the City Council and County Board of Supervisors. The SMMP must also be approved by the regulatory agencies including the ACOE, USFWS, NMFS, Regional Board, and the Calif. Dept. of Fish and Game before it can be fully implemented. It is anticipated these programs will be in effect for planning and project design beginning no later than January 2003.

8.2 Project Prioritization

The SLO watershed community, including the public and private stakeholders will need to spend over $28 million dollars over the next ten years to address the major water resources management problems identified in this WMP. Private bank stabilization and creek enhancement will add additional costs. Follow up planning, detailed design and cost estimating, and project permitting work tasks will need to be completed before construction can be initiated. Some of the problems, such as flooding through the Mid-Higuera area, have been occurring since the community was first settled in the early 1700's, and it is not realistic to think that these problems can be easily and readily solved in a short time frame. Because of the large number of individual projects that constitute the Preferred Project, it is helpful to prioritize the projects so that the follow up planning and engineering studies, and the arrangement and allocation of project funding can proceed in an orderly manner. The recommended Project Prioritization, as determined by the Zone 9 Advisory Committee, is shown in **Table 8-1**. The table also indicates the lead agency recommended to tackle the projects.

8.3 Funding Background

Potential sources of financing the programs in the WMP, including the SMMP, Bank Stabilization and Habitat Enhancement Programs, and the Flood Control Preferred Projects are reviewed in this section and Section 8.4.

Selection of the ultimate financing mechanism for each kind of project should be based on:

Table 8-1
Preferred Channel Improvement Priorities

Project	Location	Priority	Years to Complete	Lead Agency
San Luis Obispo Creek				
SLO-1	Channel Modification Below LOVR, LOVR Culvert And Bridge Replacement	I+	3-5	City
SLO-2	Elks Lane Bypass Channel	II	8-15	City/Private
SLO-3	Mid-Higuera Bypass Channel	I+	3-5	City
SLO-4	Cuesta Park Detention Enhancement	I	5-7	City
Stenner Creek				
ST-1	Santa Rosa St. Bridge Replacement	II	8-15	City
ST-2	Murray St. Bridge Replacement	I	5-7	City
ST-3	Foothill St. Bridge Replacement	I	In progress	City

- Who or what is causing the problem(s), and is therefore potentially responsible for helping to correct it;

- Who (and in which reach) would benefit the most (directly or indirectly) from implementation of the specific WMP project;

In addition to tangible benefits of protection from flood damage, improved water quality, enhanced property values, and reduced erosion, there are also intangible project benefits to the larger SLO community, such as improved traffic flow during storm events, public safety, and environmental restoration. These benefits are not included in the **Section 7** Cost/Benefit analysis, and costs associated with these benefits may be most appropriately paid by the greater watershed community.

It should be noted that the cause of the problem (especially historic flooding problems) and the entities that benefit from the restoration project are not always easy to determine. However, the following can be summarized, based on the results of the hydrologic and hydraulic modeling and field inventories:

- Flooding problems are historic and natural and not highly related to recent watershed development in most areas;

- Watershed development hasmost significantly impacted low-return period events, such as the 10-year flood, some reaches (mid-Higuera) have been affected more by overall watershed development than others although it should be noted that the mid Higuera area has always historically flooded;;

- Bank erosion, sedimentation, water quality problems, and habitat degradation are more directly linked to watershed-wide urban development than are flooding problems, and a funding program for these management needs should consider distributing costs more broadly among stakeholders;

- Problems are not solely related to urban development. Rural land uses, including roads and utilities (County and private) in the upper watershed, historic water supply reservoirs that have trapped sediment and changed stream dynamics, fire, and agricultural land uses have all impacted the creeks of the watershed.

- Stream realignment associated with highway construction (especially through mid-Higuera) in the 1950's is also a significant local contributor to flooding and bank erosion. Although the causes are a result of watershed-wide development, the Preferred Project channel modifications in this area will primarily benefit property owners in this specific reach.

- SLO channel widening at LOVR also benefits the area along Prefumo Creek and west of Highway 101, as would channel improvements in the Elks Lane area (if the flow split across Highway 101 is corrected). In this area, it is difficult to determine who benefits and how much. A benefit assessment engineer's report would be needed to allocate benefits and apportion costs.

8.4 Potential Local Financing and Funding Sources

The WMP contains a diversity of projects, and multiple sources of funding are likely, depending on the nature of the project element. Some project elements may be funded by more than one program or source, with the City or Zone 9 assembling local sources of revenue together with assistance, grants and/or loans from State or Federal agencies. **Table 8-2** summarizes possible sources of funds that should be considered as Preferred Projects move forward in the planning and design stage, as approved by the Zone 9 Advisory Committee. Funding sources include:

8.4.1 Zone 9 Funds

The San Luis Obispo County Flood Control and Water Conservation District was established in 1945 by an act of the State Legislature. Zone 9, which comprises the SLO watershed, was formed as a separate management zone within the overall District in 1973. The Zone in concert with the District can assume responsibility for powers of assessment and bonding for financing for facilities construction based on a vote of affected property owners. This includes an annual *ad valorem* assessment on all property in the district (zone) to pay administrative costs and to carry out drainage improvement projects,

including flood control and bank repair. Zone 9 also has the legislative authority to establish Benefit Assessment Districts. Zone 9 can act as the responsible local authority for projects constructed jointly with the State and Federal government.

Table 8-2: Funding Matrix

Project	Description	Zone 9	CIP	Benefit Assessment District	Mello-Roos District	Landscape/Lighting District	Drainage Utility	Development Impact	Land Development Fee	Subdivision Drainage Fee	Transit Occupancy Tax	Private Development Funded	FEMA	Flood Mitigation Assist	Community Assistance	Corps Flood Control	Corps Section 205	CA Riverine	CA Urban Streams	Other Grants
SLO-1	LOVR Culvert/Bridge Replacement	X	X																	X
SLO-2	Elks Lane Bypass Channel			X				X	X	X		X				X	X	X	X	X
SLO-3	Mid-Higuera Bypass Channel	X	X	X				X				X								
SLO-4	Cuesta Park Detention Enhancement	X	X					X		X			X	X	X		X			X
ST-1	Santa Rosa St. Bridge Replacement		X																	X
ST-2	Murray St. Bridge Replacement		X																	X
ST-3	Foothill St. Bridge Replacement		X																	X
	Airport Area Channel Modifications			X	X			X	X	X										
	Channel Management-Airport Area			X		X					X	X								
	Habitat Restoration and Enhancement	X	X				X	X	X	X	X	X					X	X	X	X
	Wet and Dry Floodproofing											X	X	X	X					X
	Floodprone Properties Land Acquisition	X	X	X				X	X	X	X	X	X	X	X		X		X	X
	Building Elevation and Relocation	X	X	X				X				X		X	X				X	X
	SMMP Bank Repair Program-Public Lands	X	X					X		X									X	X
	SMMP Bank Repair Program-Private Lands											X							X	
	SMMP Veg. Management- Public Lands	X						X		X							X		X	X
	SMMP Veg. Management- Private Lands		X									X								
	NPDES Phase II Stormwater Quality Program	X					X				X	X								

In addition:

- The current annual assessment is $.08 per $100.00 of assessed property value. This raises about $250,000.00 annually, an amount insufficient to pay for a major drainage improvement or large bank repair projects.

- Since the Zone includes both City and County unincorporated areas, revenues for maintenance projects are currently split 80% City and 20% County, based on revenue source.

- The City has typically been responsible for stream maintenance and bank repair on public lands within city boundaries, and Zone 9 for unincorporated areas.

- Major City or County projects (such as bridge replacement or flood control) are not funded by the annual *ad valorem* assessment. Funding could come from the City or County General Fund, from the sale of Bonds or other mechanisms.

8.4.2 Capital Improvement Program (CIP)

The City and County use their Capital Improvement Program as a way of planning, prioritizing and financing long-term major expenditures for infrastructure needs, such as parking structures, streets and interchange improvements, park and recreation facilities, and administrative facilities. Planning for major capital improvements is a formal process where the City or County identify long-term needs and expenditures, and establish them in a CIP account. Previous major CIP recommended expenditures for flood control were listed in the City's 1983 Flood Policies or "Pink Book", which this WMP replaces.

Financing for capital improvements can come from the sale of special municipal bonds, with revenue for major projects often assembled from a variety of General Fund sources, including sales and property taxes, use fees, grants and loans from the state and federal government, and redevelopment agency sources.

This funding method is best suited for projects with citywide benefits, such as bridges, or there is a general obligation to repair community-based problems.

8.4.3 Benefit Assessment District

A Benefit Assessment District is a common method to fund projects where the construction of improvements needs to be completed over a large, contiguous area or areas, instead of an individual parcel, but generally not over an entire City. Under this funding mechanism, the City or County builds the project on behalf of property owners, and then the property owners or businesses are assessed levies proportional to the benefits that they receive from the construction of direct and measurable benefit to the area.

Formation of a Benefit Assessment District usually requires the City or County to prepare an Engineering Report that defines project needs, construction details, and costs. The boundaries of the proposed District include only the properties that receive a benefit, and a formula is derived to determine how benefits and levies are to be assessed. An assessment is then completed to determine the benefits to each parcel, with the corresponding assessment or levy based on proportionate benefits and costs.

The City or County proposing formation of the Benefit Assessment District must provide a written notice to all property owners in the proposed District of the intention to form a District. At least one public hearing is held to consider formation of the District, and property owners who oppose District formation are required to notify (in writing) the City or County with their objections. District formation requires a simple majority of property owners, and an election is held if it appears that there is opposition to the project or formation of the Benefit Assessment District.

Benefit Assessment District formation should be considered to pay for a portion of flood control improvements in the Mid-Higuera area, combined with other citywide generated funds. This is because the improvements are needed to offset the effects of Citywide or watershed wide development, and benefits, (for instance traffic flow along South Higuera Street) accrue to a larger area.

8.4.4 Mello-Roos District

A Mello-Roos Community Facilities District is a financing tool to levy special taxes for designated community improvements, such as freeway interchanges, library service, or recreation programs. They can also be used to construct basic storm drain infrastructure. To levy a Mello-Roos tax, the area's voters must consent to being taxed. A two-thirds approval vote is required, since Mello-Roos is a special tax. This makes Mello-Roos formation difficult.

Most Mello-Roos Districts are established prior to development and used to finance basic infrastructure. Drainage improvements in the Airport area, including modifications to the East Fork of SLO Creek, construction of regional detention facilities, and other non-drainage infrastructure could be considered for funding with a Mello-Roos District.

8.4.5 Landscape and Lighting District

A Landscape and Lighting District (LLD) is similar to a Benefit Assessment District, in that it applies to a specifically defined area that receives an annual service, such as landscape maintenance of common areas. The LLD is a Special District created by the City or County, which assesses an annual fee for service related to long-term maintenance (where maintenance needs and costs vary over time). Formation of the LLD requires two-thirds approval vote by the property owners. For the WMP, a LLD is:

- Appropriate for long-term intensive vegetation management in common areas;

- Work could be contracted out annually and tied to the Annual Work Plan of the SMMP;
- Zone 9 Advisory Committee recommended the LLD funding concept be considered only for long-term maintenance of stream restoration work in the Airport area.

8.4.6 Stormwater or Drainage Utility Fees

A City-wide Stormwater or Drainage Utility Fee is currently being formulated by the City for implementation of its impending Phase II NPDES Storm Water Quality Program. Fees paid into the Drainage Utility are not considered a tax, but a use fee for users of the public storm drainage system. The fee will likely be collected as part of the city's utility bill on a monthly (or periodic) basis with the fee based on a formula determined by land use, parcel size, and square footage of impervious surface area.

The fee is being established specifically for water quality improvements, so any use of funds from this source must be related to water quality issues. Other communities (City of Santa Rosa and Santa Clara County) have considered creek restoration work to benefit water quality by providing shading and biofiltering along top of bank buffer strips.

A comparable Drainage Utility Fee could also be developed within the County area, and the County is beginning to investigate their Phase II NPDES storm water management needs. The Zone 9 Advisory Committee recommended that use of Drainage Utility fees be considered for creek restoration related water quality improvements, but not for flood management or bank repair.

8.4.7 Development Impact Fees and Biological Impact Fees

A Development Impact Fee is a one-time charge associated with the impacts of a development project, as determined in a project CEQA document. Impact fees are commonly assessed to provide for schools, parks, open space, and traffic issues, but are less commonly applied to drainage impacts (although some cities apply such fees). Drainage impact fees are typically based on square footage of new impervious surface area, a calculated net increase in runoff measured in acre-feet per year, or possibly a calculated increase in creek flow. Such fees can be used to build regional detention facilities or make improvements to undersized storm water drainage systems. However, since the City is about 85% built out, the collection of impact fees will be limited in the future, and would best be used to pay for improvements that can be directly linked to a proposed project. Other considerations include:

- Fees may be as high as $30,000.00 per acre foot of increased runoff (City of Petaluma);
- *Biological Impact Fees* are less common; often used for wetlands, stream zones and endangered species habitat;

- Fees are typically based on acreage impacted, but can be based on lineal feet of stream impacted (e.g. for a bank repair project)
- Stream zone impact fees may range from $10,000-40,000/impacted acre, or $50- $200.00/l.f. of stream, based on probable restoration costs;
- Fees can be used to support regional habitat enhancement projects. The concept is similar to a Mitigation Bank, but not necessarily with a formal bank established.

8.4.8 Land Development Fees

A Land Development fee is another option available to cities and counties to fund drainage and flood control improvement projects, especially where the benefits are spread out over a wide area of new development. Such fees were authorized by the State of California Flood Control Act of 1970, and are used in Ventura County. Currently there is a maximum fee that can be levied: $2,400/acre, or $600/single family dwelling. These fees may be insufficient to pay for required drainage improvements.

Like the Drainage Impact Fee, and since the City is about 85% built out, this option is appropriate only for large new residential and commercial developments where needed drainage improvements are very modest.

8.4.9 Subdivision Drainage Fees

The Subdivision Map Act of the State of California authorizes cities and counties to adopt an Ordinance requiring the payment of one-time fees as a condition of approval of a subdivision map (for a new development). A drainage fee Ordinance, (and the subsequent collection of subdivision drainage fees) based on this Act must:

- Refer to a Drainage Master Plan adopted for a particular drainage area which contains an estimate of the total costs of construction of the needed drainage improvements and facilities required by the plan, and a map of such areas showing the drainage area boundaries and the location of improvements and facilities;

- State that the drainage plan conforms by resolution to a City or County approved Drainage Master Plan for the area;

- Be based upon a legislative determination of costs that are fairly apportioned and based on the need for such improvements and facilities as created by development of properties in the fee collection area, and;

- Set fees that reflect a pro-rata share of drainage facility costs, (i.e. the gross facility costs for each zone divided by the total gross acres in each zone).

One difference between these fees and others is that the project must involve a subdivision of land in order to collect these fees. Some large-scale commercial developments do not necessarily involve the subdivision of land.

8.4.10 Sales Tax and Transient Occupancy Tax

Some communities impose a local Sales Tax or a Transient Occupancy Tax (hotel bed tax) to pay for specific programs, such as street improvements. The City of Santa Barbara uses a Transient Occupancy Tax to fund water quality and creek restoration efforts. Although these revenue sources can raise substantial sums of money annually, a local sales tax requires authorization by the state legislature and both sales and bed taxes require a two-thirds approval by voters in the affected area. In addition, sales taxes are considered a regressive tax, as they disproportionately affect some income groups, are not readily associated with problem causes and beneficiaries, and may make local businesses less competitive with other nearby businesses that do not impose such taxes.

8.4.11 Private Development Funding

It is common for developments adjacent to privately owned stream channels (with flooding or bank instability problems) to have the needed channel improvements completed by the developer. The channel is later offered for dedication to the City or County, following a period of developer-funded maintenance and monitoring. The Drainage Design Manual outlines the design requirements and procedures for privately funded and constructed channel modifications.

- Private development projects and any proposed channel modifications would require separate CEQA review, approval, and agency permitting.

- This method of funding is most appropriate for land development projects where flooding affects vacant private land, and where there is little direct public benefit from the channel modifications that would be constructed privately, other than as project impact mitigation.

- Private funding would not work where a nearby channel with flooding problems is not under the control of the developer, or where development may have off-site drainage impacts.

- Private funding of approved channel modifications in the Elks Lane area is a possibility, although the situation is complicated by multiple property owners and wider public benefit of flood control in this area, especially control of flood overflow of Highway 101.

8.5 State and Federal Funding Programs

A variety of State and Federal programs are potentially available to the City and Zone 9 for flood control, bank stabilization, and stream restoration purposes. Many of these programs

are moving away from funding hard structural flood control projects in favor of projects that emphasize non-structural programs such as building elevation, building relocation, and acquisition of flood prone areas. The most successful projects in terms of achieving grant funding have significant stream restoration and enhancement components, emphasize biotechnical bank stabilization, and have strong local stakeholder support and involvement. Most programs also preclude eminent domain condemnations for property acquisition, which makes grant funding of portions of the Mid-Higuera project problematic. However, communities that have developed comprehensive watershed-based projects (such as this WMP) usually rank higher in the increasingly competitive grant funding process.

8.5.1 FEMA Programs

<u>406 Flood Hazard Mitigation Program</u>

- Requires declaration of a Federal Disaster Area
- Application required within 60 days of declaration (concept plans must be ready)
- Many kinds of projects funded, including design, bank repair, vegetation management, channel modifications, and detention basins
- Typical split is 75% Federal; 25 % state or local funding
- Flood Hazard Mitigation Grants will be harder to obtain in the future

<u>Flood Mitigation Assistance (FMA)</u>

- Federal program available through Department of Water Resources Floodplain Management Office
- Competitive program for mitigation; state selects recommended participants-communities

<u>Community Assistance Program (CAP)</u>

- Product-oriented assistance to Community for floodplain management
- Could potentially be used to help with National Flood Insurance Program (NFIP) and Community Rating System (CRS)
- SLO currently has a rating of 8 (lower is better) entitling a 10% reduction in flood insurance premiums (total is about $200,00/yr)
- An aggressive NFIP-CSR could lower the rating, some of the work in this WMP, comprehensive plan, community meetings, education and outreach, flood proofing, could lower CSR

- DWR and ACOE Section 206 Floodplain management programs may also help with CSR

8.5.2 ACOE Flood Control Programs

Individually Authorized - Large Flood Control Projects

- Typically requires a ACOE feasibility study, but can be completed by a City or County
- Requires direct Congressional authorization and funding
- Often takes 7-10 years or more from study initiation until completion
- Subject to substantial schedule delays and cost over-runs
- Designs sometimes neither innovative nor environmentally friendly
- Large backlog of individually authorized projects means this program is in doubt, especially for new structural flood control projects

8.5.3 Section 205 Program-Small Flood Control Projects

- Requires feasibility study and favorable cost/benefit ratio
- Cost share is 50% feasibility, 35 % local for construction, $7,000,000 Federal funding cap
- Local partner is responsible for lands, easements, rights-of-way, relocations, and spoil disposal
- Competitive and time consuming process
- Reform pressure to tighten up cost/benefit analysis, consider environmental impacts more fully, adopt mitigation standards applied to private projects, and reduce benefits to private undeveloped properties

8.5.4 Section 212 -Flood Mitigation and Riverine Restoration Program

- Program emphasizes non-structural approaches to preventing or reducing flood damage, such as floodplain purchase and building relocation
- Riparian restoration also an important program element
- Cost share is 50% feasibility, 35 % local for construction, $30,000,000 Federal cap

8.5.5 State Grants

Proposition 12 (Parks Bond), Proposition13 (Water Bond) were passed by State voters in 2000, and Proposition 40 (2001) include elements for flood control and habitat enhancement and restoration.

These are very competitive grants, but awards can range from $100,000.00 to $1,000,000.00.

Riparian and Riverine Habitat Grant Program

- Competitive program for public education, awareness, recreational access, and enjoyment
- Administered by Calif. Dept. of Parks and Recreation, $10,000,000 total funding
- Covers acquisition, development, improvement, and restoration of open space areas along rivers and streams
- Competitive, grants from $20,000-$400,000, Feb. 1 application
- Other California Department of Parks and Recreation Department programs annually funded include Land and Water Conservation Fund, and Habitat Conservation Fund, as the State contributor to these competitive Federally funded programs.

Urban Streams Restoration Program

- Competitive program for creek and floodplain management
- Administered by California Department of Water Resources
- Requires a local non-profit partner or watershed group
- Comprehensive, watershed based approach, and involvement of multiple agencies in multi-objective planning is important
- Focus on non-structural projects, such as land acquisition and habitat enhancement
- Emphasis is on implementation, not studies; projects must have CEQA approval
- Cuesta Park Project, coupled with habitat enhancement in Reach 14 is strongest candidate for Grants - possibly Mid-Higuera vegetation management and habitat enhancement

- Grant cycle twice a year, fall and spring, several hundred thousand dollars available

Other Grants

- Caltrans funds potentially available to help mitigate impacts of previous highway projects

- Many other grant programs available from Coastal Conservancy, US Fish and Wildlife Service, Dept. of Fish and Game, etc. -best accomplished in association with non-profit partner.

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10. GLOSSARY OF TECHNICAL TERMS

Aggradation. The geologic process by which streambeds and floodplains are raised in elevation by the deposition of material.
Alluvial. Deposited by running water.
Anadramous. Fish that leave freshwater and migrate to the ocean to grow, and return to freshwater to spawn.
Armoring. (a) The natural process of forming an erosion resistant layer of relatively large particles on the surface of the streambed. (b) The artificial application of various materials to strengthen streambanks against erosion.
Axil. The angle between the upper side of a leaf and its supporting branch or stem.
Bankfull Discharge. The discharge corresponding to the stage at which the natural channel is full. This flow has a recurrence interval of 1.5 to 4 years depending on the channel gradient and bank materials.
Bar. (a) Accumulation of alluvial material along the banks, midstream, or at the mouth of a stream or in the wakes of objects where a decrease in velocity induces deposition. (b) An alluvial deposit composed of sand, gravel, and other material that obstructs flow and induces deposition or transport.
Base flow. Can be defined as the volume of flow in a stream channel that is not derived from surface run-off. Base flow is characterized by low-flow regime (frequency, magnitude, and duration daily, seasonally, and yearly), by minimum low-flow events and in context of the size and complexity of the stream and its channel.
Bed load. Sediment moving along or near the streambed and frequently in contact with it.
Bed slope. The inclination of the channel bottom.
Bend. A change in the direction of a stream channel.
Benthic. Of or pertaining to animals and plants living on or within the substrate of a water body.
Berm. A levee, shelf, ledge or bench along a streambank that may extend laterally in the channel to partially obstruct flow, or parallel to the flow to contain the flow within its streambank. May be natural or constructed.
Best Management Practice. A practice used to reduce impacts from a particular land use.
Biotechnical approach. An applied science that combines structural, biological and ecological concepts to construct living structures for erosion, sediment and flood control.
Blanket. Material placed on a streambank to cover eroding soil.
Boulder. Sediment particle having a diameter greater than 256 mm (10 inches).
Brush layer. Live branch cuttings crisscrossed on trenches between successive benches of soil.
Brush mattress. A mattress-like covering that is placed on top of the soil. The covering material is living wood plant cuttings that are capable of rooting.
Buffer. A vegetated area of grass, shrubs or trees designed to capture and filter runoff from surrounding land uses.
Canopy. The overhead branches and leaves of riparian vegetation.
Canopy cover. Vegetation projecting over a stream, including crown cover (generally more than 3 feet above the water surface) and overhand (less than 3 feet above the water surface).
Channel. A natural or man-made waterway that continuously or periodically passes water.
Channel roughness. The irregularity of streambed materials sizes and channel form in plan and cross-section that causes resistance to flow.
Channel scour and fill. Erosion and sedimentation that occurs during relatively short periods of time; *degradation* and *aggradation* apply to similar processes that occur over a longer period of time.
Channel stability. A relative measure of the resistance of a stream or river to erosion. Stable reaches do not change markedly in appearance from year to year.
Check dam. A structure placed bank to bank downstream from a headcut.
Clay. Cohesive soil whose individual particles are not visible to the unaided human eye. Soil can be molded into a ball that will not crumble.
Cobble. Sediment particles larger than pebbles and smaller than boulders. Usually 64 - 256 mm (3 to 8 inches) in diameter.
Coir. A woven mat consisting of coconut fibers. Generally used for various soil erosion control practices such as surface slope protection and the construction of geogrids.
Cover. Anything that provides protection for fish and/or wildlife from predators or ameliorates adverse conditions of stream flow and/or seasonal changes in metabolic costs. May be instream structures such as rocks or logs, turbulence, and/or overhead vegetation. Anything that provides areas for escape, feeding, hiding, or resting.

Cribwall. A hollow structural wall used for bank and slope stabilization formed by mutually perpendicular and interlocking members (usually timber) into which live cuttings are inserted along with soil to stabilize roots.
CRLF. Calfornia Red legged frog.
Cross section. A vertical section of a stream channel or structure that provides a side view of the structure; a transect taken at right angles to flow direction.
Culvert. A sewer or drain crossing under a road or embankment.
Current. The flow of water through a stream channel.
Cutbank. The outside bank of a bend, often eroding and across the stream from a point bar.
D_{30}, D_{50}, D_{100}. The particle size for which 30, 50, and 100 percent of the sample is finer.
Debris. Any material, organic or inorganic, floating or submerged, moved by a flowing stream.
Deflectors. Structures used to deflect stream flow to a different location, usually away from an eroding bank.
Degradation. The long-term hydraulic process by which stream and river beds lower in elevation. It is the opposite of aggradation.
Deposition. The settlement of material out of the water column and onto the streambed or floodplain. Occurs when the flowing water is unable to transport the sediment load.
Development. A man-made change to improved or unimproved real estate. This includes, (not limited to) buildings and other structures, mining, dredging, filling, grading, paving, excavation, and drilling operations.
Dike (groin, spur, jetty, deflector). A structure designed (1) to reduce the water velocity as streamflow passes through so that sediment deposition occurs instead of erosion (permeable dike) or (2) to deflect erosive currents away from the streambank (impermeable dike).
Discharge. The volume of water passing through a channel during a given time, usually measured in cubic feet per second.
Dredge material. Soil excavated from a stream channel.
Encroachment. Any fill, structure, building, use, accessory use, or development in the floodplain or watercourse.
Energy dissipation. The loss of kinetic energy of moving water due to internal turbulence, boundary friction, change in flow direction, contraction or expansion.
Enhancement. Improvements to the existing conditions of the aquatic, terrestrial, and recreational resources.
Erosion. In the general sense, the wearing away of the land by wind and water. As used in this pamphlet, the removal of soil particles from a bank slope primarily due to water action.
ESA. Endangered Species Act
Failure. Collapse or slippage of a large mass of bank material into a stream.
Fascines. Sausage-like bundles of plant cuttings used to stabilize streambanks and other slopes (see *wattles)*
FEMA. Federal Emergency Management Agency. The agency which administers the NFIP at the federal level.
Fill material. Soil that is placed at a specified location. to bring the ground surface up to a desired elevation.
Filter. Layer of fabric, sand, gravel, or graded rock placed between the bank revetment or channel lining and soil for one or more of three purposes: to prevent the soil from moving through the revetment; to prevent the revetment from sinking into the soil; and to permit natural seepage from the streambank, thus preventing buildup of excessive groundwater pressure. If a filter is used by a landowner or local government, technical assistance should be obtained to properly match the filter with the soil.
Fine particles (or Fines). Silt and clay particles.
Fish habitat. The aquatic environment and the immediately surrounding terrestrial environment that meet the necessary biological and physical requirements of fish species during various life stages.
Flood. A general and temporary condition of partial or complete inundation of normally dry land areas.
Flood insurance rate map (FIRM). The official Flood Insurance Administration map which shows special hazard zones and risk areas of a community. This map is used for insurance rating purposes.
Floodplain. An area of land that would be covered with water during a flood. In connection with the Flood Insurance Program, the term usually refers to the 100-year floodplain. The term is identical to “flood hazard area”.

Floodway. The river channel and overbank areas of riverine floodplains through which the base flood is discharged. This portion of the floodplain is where the highest flood velocities and greatest flood depths usually occur. Floodways are shown on the Flood Boundary and Floodway Maps (FBFM) prepared by FEMA for regular program communities. Upon the adoption of these maps by a community, the floodway(s) shown become "regulatory floodways" within which encroachment or obstructions must be prohibited
Fluvial. Produced by moving water.
Fluvial geomorphology. The study of surface forms produced by the action of flowing water.
Freeboard. The vertical distance between the design water surface elevation and the elevation of the bank, levee or revetment that contains the water.
Gabion. A galvanized wire basket with a hinged top, intended to be filled with stones and used to stabilize banks or channel beds, to control erosion, and to prevent bed material from shifting. Generally not recommended for placement in gravel bed streams.
Geomorphology. The geologic study of the evolution and configuration of land forms.
Gradient. Slope calculated as the amount of vertical rise over horizontal run
Gravel. Soil particles ranging from 1/5 inch to 3 inches in diameter.
Groundwater table. The depth below the surface where the soil is saturated; that is the open spaces between the individual soil particles are filled with water. Above the groundwater table and below the ground surface the soil either has no water between particles or is partially saturated.
Habitat. The area or environment in which an organism lives.
Headcutting. The action of an upstream moving waterfall or locally steep channel bottom with rapidly flowing water through an otherwise placid stream. These conditions often indicate that a readjustment of a stream's discharge and sediment load characteristics is taking place.
Headwater. The uppermost reaches of a stream or river.
Hydrology. The study of the properties, distribution and effects of water on the Earth's surface, soil, and atmosphere.
Hydraulics. Water or other liquids in motion & actions.
Hydric soils. Soils found in saturated, anaerobic environments usually characterized by a gray or mottled appearance, often found in wetlands.
Impermeable material. A soil that has properties which prevent movement of water through the material.
Incised channel. A stream that has cut its channel into the bed of the valley.
Infiltration. The portion of rainfall that moves downward into the subsurface rock and soil.
Instream. The instream channel includes the channel bottom up to 10 feet minimum above the Ordinary High Water (OHW) mark, or the 2-year peak flow line.
Instream cover. (a) Areas of shelter in a stream channel that provide aquatic organisms protection from predators or competitors. (b) A place in which to rest and conserve energy due to a localized reduction in the force of the current.
Intermittent stream. A stream that has interrupted flow or does not flow continuously.
Joint planting. The process of placing live woody plant cuttings in the spaces between pieces of rock rip-rap. When placed properly, the cuttings are capable of rooting and growing.
Large woody debris. Any large piece of woody material that intrudes or is embedded in the stream channel. Also called large organic debris.
Live Stakes. Cuttings from living branches that are inserted into the soil to stabilize slopes and streambanks when the cuttings root and grow.
Maintenance. The ***repair, care and upkeep*** of a channel at a pre-existing or approved design condition, within a designated flow conveyance capacity.
Management. Modification, alteration and change, where necessary, of physical and biological site conditions in response to evolving goals, objectives and changing environmental conditions.
Manning's "n". The resistance coefficient in the Manning formula used in calculating water velocity and stream discharge. It is a proportionality coefficient that varies inversely as a function of flow.
Meander. A circuitous winding or bend in the river.
Mean sea level (MSL). The average height of the sea at all stages of the tide. Mean Sea Level is also referred to as "National Geodetic Vertical Datum" (NGVD).
Obstruction. Any structure or assembly of materials including fill above or below the surface of land or water, and any activity that might impede, retard or change flood flows.
OHW. Ordinary high water mark. See below.
One-hundred year flood. Another name for the base flood, the flood having a one-percent of occurring in any single year.

Ordinary high water mark. The mark along a streambank where the waters are common and usual. This mark is generally recognized by the difference in the character of the vegetation above and below the mark or the absence of vegetation below the mark.
Overbank flow. Water flowing over the top of bank.
Perennial stream. A stream that flow continually.
Point bar. A gravel or sand deposit on the inside of a river bend; an actively mobile river feature.
Pool. Deeper areas of a stream with slow-moving water, often used by larger fish for cover.
Pool-riffle ratio. The ratio of pool and riffle areas, or pool and riffle length in a given stream reach.
Program. San Luis Obispo Creek Stream Management and Maintenance Program***Reach***. A relatively homogeneous length of stream having a similar sequence of characteristics.
Riffle. A shallow section in a stream where water is breaking over rocks or other partially submerged organic debris and producing surface agitation.
Riparian area. The area between a body of water and adjacent upland areas that is identified by distinctive soil and vegetative characteristics.
Riparian buffer. Trees and shrubs growing parallel to a stream that reduce the intrusion into the top bank area by humans, animals, and machinery. This vegetation also retards surface runoff down the bank slope and provides a root system which binds soil particles together.
Riparian vegetation. Vegetation growing along the banks
of streams and rivers or other bodies of water tolerant to or more dependent on water than plants further upslope.
Riparian zone. The vegetated zone adjacent to a stream or any other water body (from the Latin work ripa, pertaining to the bank of a river, pond or lake).
Rip-rap. A layer, facing, or protective mound of stones placed to prevent erosion, scour, or sloughing of a structure or embankment. Also refers to the stone used.
Roughness element. Any obstacles in a channel that deflect flow and change its velocity.
Run. The straight fast-moving section of a stream between riffles.
Salmonids. Fish of the family Salmonidae, including salmon, trout, char, whitefish, ciscoe, and grayling.
Sand. Mineral particles ranging from 0.0625 to 2 mm (0.0025 to 0.08 inch) diameter; 0.03 inch is the normal lower limit at which the unaided human eye can distinguish an individual particle.
Scour. Concentrated erosive action of flowing water in streams that removes material from the beds and banks.
Sediment discharge. Mass of sediment passing a stream cross-section at a defined unit of time.
Sediment load. The sediment transported through a channel by streamflow.
Sediment. Soil particles that have been transported and/or deposited by wind or water action.
Shear strength. The internal resistance of a body to shear stress. Typically includes frictional and cohesive components. Expresses the ability of soil to resist sliding.
Shear stress. The force per unit area tending to deform a material in the direction of flow.
Sheet erosion. The removal by surface runoff of a fairly uniform layer of soil from a bank slope.
Silt. Slightly cohesive to noncohesive soil composed of particles that are finer than sand but coarser than clay, commonly in the range of 0.004 to 0.0625 mm. Silt will crumble when rolled into a ball.
Sinuosity. A measure of the amount of a river's meandering; the ration of the river length to the valley length. A straight channel has a sinuosity of 1.0; a fully meandering river has a sinuosity of 2.0 or greater.
Slope. Vertical rise divided by horizontal run.
Sloughing (or sloughing off). Movement of a mass of soil down a bank into the channel (also called slumping). Sloughing is similar to a landslide.
Slumping. The collapse of slopes by undercutting.
Specifications. A detailed description of particulars, such as size of stone, quantity and quality of materials, contractor performance, terms, quality control, and equipment.
Stream. A body of running water moving over the Earth's surface in a channel or bed (also river).
Streambank. The portion of the channel cross section that restricts lateral movement of water at normal water levels
Streambank erosion. Removal of soil particles from a bank slope primarily due to water action. Climatic conditions, debris, chemical reactions, and changes in land and stream use may also lead to bank erosion.
Streambank failure. Collapse or slippage of a large mass of bank material into the channel.
Streambed. The substrate plane bounded by the stream banks over which water moves. Also called stream bottom. It is the area kept mostly or completely bare of vegetation by the wash of waters in the stream.
Streamflow. The movement of water through a stream channel.

Structural. Reducing flood hazards through physical means, such as dams, dikes, levees, or channelization of rivers or streams.
Structure. (a) Any object in the channel that affects water and sediment movement. (b) The diversity of physical habitat within a channel.
Substrate. The mineral or organic material that forms the bed of the stream.
Surface runoff. That portion of precipitation that moves over the ground toward a lower elevation and does not infiltrate the soil.
Thalweg. A line following the deepest part of the bed or channel of a stream.
Toe. The break in slope at the foot of a bank where the bank meets the bed.
Top of bank. The break in slope between the streambank and the surrounding upland terrain.
Transect. (a) A predetermined line along which vegetation occurrence or other characteristics such as canopy density are counted for monitoring purposes. (b) A channel cross-section.
Turbidity. Relative water quality conditions; measure of light passing through water affected by suspended material.
Upper bank. That portion of the streambank above the elevation of the average water level of the stream.

Vegetated geogrid. Soil wrapped with a geotextile fabric and with live woody plant cuttings placed in between each soil/geotextile wrap.
Velocity (of water in a stream). The distance that water can travel in a given direction during an interval of time.
Waters of the United States. Includes all dry land and water-covered areas below the ordinary high water marks on navigable and non-navigable streams.
Watershed. An area of land that drains into a particular river or body of water. Usually divided by topography.
Wattling. See fascines.
*Wetlands.*terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands have one or more of the following three attributes: (a) At least periodically, the land supports predominantly hydrophytes; (b) The substrate is predominantly undrained hydric soil; and, (c) the substrate is nonsoils and is saturated with water or covered by shallow water at some time during the growing season of each year.
Woody debris. Coarse wood material such as twigs, branches, logs, trees, and roots that fall into streams.

APPENDIX A

GIS Inventory Data

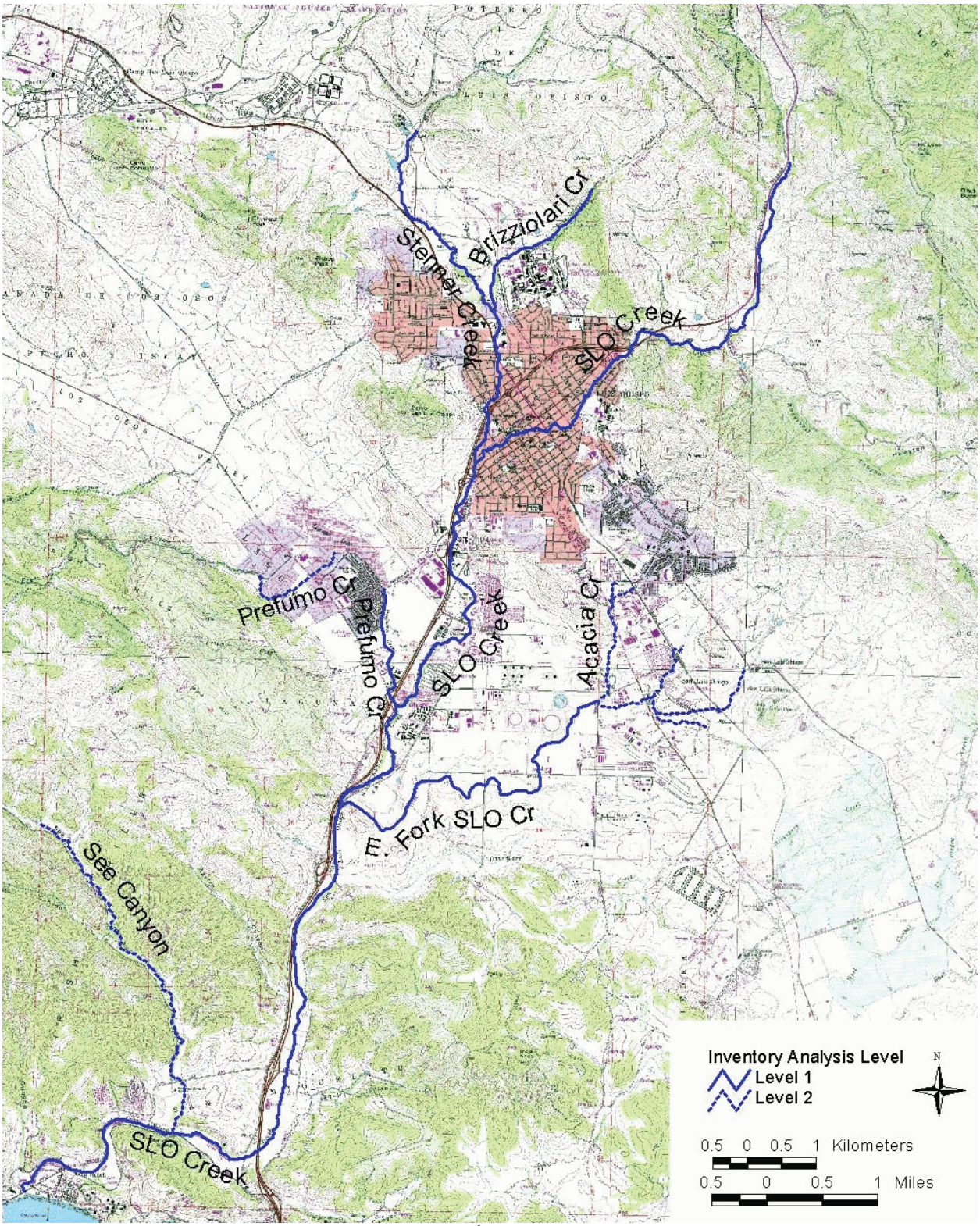
Hydraulic and Geomorphologic Field Inventory

The purposes of the hydraulic and geomorologic inventory performed as part of the San Luis Obispo Waterways Management Plan (WMP) are three-fold. First, the inventory is meant to identify banks and hydraulic structures that are at risk of failing in the foreseeable future, to quantify that risk, and to help identify whether projects at these sites could potentially increase the risk of failure on nearby banks. Second, the inventory classify's the stream system into a set of reaches containing similar geomorphic properties. Finally, the inventory will provide an existing baseline condition for the stream channel system.

The watershed inventory was performed during the spring, summer, and fall of 2000. Collected data included both hydraulic and geomorphic features such as eroding stream banks, existing structures, and grade breaks. A separate inventory of biological features (i.e. the type and quality of available habitat, the presence of endangered or exotic species, etc.) was performed concurrently by the Morro Group and is described in **Appendix B**.

The inventory was intended to cover the majority of the major perennial flow channels within the San Luis Obispo Creek Watershed. Each channel within the watershed was divided into one of three types. This classification is shown in **Figure A-1**. *Type 1* channels received the most detailed inventory, involving a team of technicians walking the entire channel and recording features in the field. The same types of data were recorded for *Type 2* channels, but since portions of these channels were either relatively inaccessible or ran through private property, or since a quick look at the channel was often sufficient to characterize the problems there, they were not walked in their entirety by the technical team. Instead, as many features as possible for these reaches were identified from accessible points at the top of bank or from bridges. *Type 3* channels were typically found high in the watershed (and are not specifically identified in **Figure 1**). Spot visits to these channels were performed as part of the survey, but the primary work here involved interpretation of orthophotographs and other existing maps.

Figure A-1
Field Inventory Methods - (Level 1 and 2 Channels)



The features included in the inventory were bank erosion sites, stream channel reaches, hydraulic structures, hydraulic obstructions, grade breaks in the channel profile, culvert outfalls, bedrock occurrence, and bridges. A detailed description of these features and their attributes is included at the end of this Appendix. Because of the geographical nature of the collected data, the results of the inventory are stored using a Geographic Information System (GIS). Data is available from the City of San Luis Obispo Geodata Services Department, at 955 Morro Street, San Luis Obispo, CA 93401. Most of the data is available online at http://suntzu.larc.calpoly.edu/slo_creek/.

For Type 1 channels (the majority of the survey), data was collected by physically walking the entire length of the stream system. When a feature requiring inventory was encountered, its position was recorded using a Global Positioning System (GPS) receiver worn by the data technician. Attributes about the feature were recorded at that point, directly in the field. For example, if a culvert outfall had been encountered, its type, size, and condition would have been recorded.

In many cases, often because of nearly vertical banks and dense vegetation, it was not possible to record the precise location of a feature while in the field. In these cases, the final position entered in the GIS data base was determined by the data collection technician back in the office using a scanned, geographically referenced aerial photograph (digital orthophotograph).

Some of the most important data collected during the inventory process were individual photographs for each significant feature. Since it was difficult to show some of the larger features in a single photograph, the photos were taken of what was considered a representative part of the feature. The photographs are accessible through the GIS database.

Detailed Descriptions of Hydraulic/Geomorphic Field Inventory Data Files

Eroding Streambanks (Erosion.shp)

Eroding streambanks are steep, sparsely vegetated sections of stream bank that in the opinion of the field technicians could experience substantial erosion during a high flow event. The goal in field data collection was to record easily measured attributes about the individual features such as feature height, type of bank and bed material, the amount of vegetation on the bank, etc.

A bank erodibility index was developed based loosely on a method described in Rosgen, 1996. This method ranked each of the raw data attributes on a scale of one to ten, with ten being the most likely to result in future bank erosion. The classification method is described in **Table A-1**. The sum of each index value resulted in a total bank erodibility index that theoretically varies from 0 to 100. (In fact, no erosion sites received an erodibility risk rating less than 31or greater than 84.) An index of 50 or greater denotes a fairly substantial erosion risk. However, even sites with index values less than 50 could become worse after future flow events and should be carefully monitored.

(Note: for most existing structures, it would be difficult to develop a system of recording raw data about the structure and then using that to develop a risk-of-failure index. It was much simpler for

existing revetments and for culvert outfalls to record the technicians' opinion of risk made in the field. Photographs of these structures can be used to confirm the technicians' opinions.)

Table A-1. Bank Erosion Data Dictionary and Erosion Risk Rating Method

Attribute	Possible Values	Description	Erosion Risk Index Value
Mechanism	Toe Scour	Entrainment of toe material into flow leads to sloughing	n/a
	Geotechnical	Characterized by rotational slumping	n/a
	Shear (deflection)	Entrainment of material all along bank by deflected flow	n/a
	Complex	Combinations of all other factors	n/a
	Vegetation factors	Willows on central bar deflected flow into bank	n/a
	Rill/gully, bank top	Caused by local tributary flow, not by flow in main channel	n/a
	Other		n/a
Location	Left Bank	Failure located on left bank (looking downstream)	n/a
	Right Bank	Failure located on right bank (looking downstream)	n/a
Toe Material	Cohesive	Material appears to have significant clay/cohesive fraction	3
	Non-Cohesive	Very little clay - material crumbles in hand	6
	Stratified	A layer of non-cohesive material surrounded by cohesive	10
	Claystone	Very dense clay-like material	0
	Bedrock	Rock outcrops visible along majority of bank toe	0
Upper Bank Material	Cohesive	Material appears to have significant clay/cohesive fraction	3
	Non-Cohesive	Very little clay - material crumbles in hand	6
	Stratified	A layer of non-cohesive material surrounded by cohesive	10
	Claystone	Very dense clay-like material	0
	Bedrock	Rock outcrops visible along majority of upper bank	0
Root Density	80-100%	Root density describes a field estimate of the surface area	3
	55-79%	of bank that is potentially bound together by roots from	6
	30-54%	vegetation present on the bank. This differs from percent	10
	15-29%	surface cover in that it is intended to characterize the	13
	5-14%	below-ground strengthening characteristics of the bankside	17
	<5%	vegetation.	20
Percent Surface Cover	80-100%	Percent surface cover represents the bank soil area directly	3
	55-79%	shielded from impinging flow by any vegetation. Here, the	6
	30-54%	vegetation is directly visible. No estimates of below-ground	10
	15-29%	root coverage need to be made, as for the Root Density	13
	5-14%	attribute.	17
	<5%		0
Riparian Habitat	Pools	Stream becomes significantly deeper and/or slower	n/a
	Instream cover	Debris/undercut bank/vegetation present below flow line	n/a
	Canopy	Stream shaded by veg that could be removed if site stabilized	n/a
(represents the type of features that could	Pools & Instream Cover	see above	n/a
potentially be changed	Pools & Canopy	see above	n/a
by a bank stabilization project at the site)	Instream Cover & Canopy	see above	n/a
	Pools & Cover & Canopy	see above	n/a
Threatened Structures	None	No structure visible from stream channel	n/a
	Main Structure	Potentially inhabitable structure	n/a

	Outbuilding	Garages/sheds etc.	n/a
	Deck or Fence	self explanatory	n/a
	Other	self explanatory, usually highway, other infrastructure	n/a
Distance to structure		estimated distance from top-of-bank	n/a
Downstream Transition	low future instability	No visible reason to expect banks would begin eroding in future, even if site stabilized with hard structure	n/a
	possible instability this bank	Changing bank structure appears to have potential to destabilize same bank just downstream	n/a
	possible instability opp bank	Changing bank structure appears to have potential to destabilize opposite bank just downstream	n/a
	possible instability both bank	Changing bank structure appears to have potential to destabilize both banks just downstream	n/a
Bank Angle	0-20	Represents angle of representative portion of bank scarp.	3
	21-60	Measured by laying surveying rod on steepest continuous	7
	61-80	part of bank and measuring angle with inclinometer.	10
	81-90		13
	90-119		17
	>120		20
Approximate length		Estimated length of failure. Used only for QC purposes.	n/a
Photo time		Time feature was recorded. Used to match with photo.	n/a
Height (m)	0-1	Height from toe to top of bank. Measured using surveying	3
	1-2	rod. Where upper bank is not level, represents distance	7
	2-3	from toe to top of scarp.	10
	3-5		13
	5-7		17
	>7		20

Revetments (revetmnt.shp)

Revetments are constructed features such as rock rip-rap or concrete walls that are intended to stabilize eroding stream and river banks.

Table A-2. Revetments Data Dictionary

Attribute	Possible Values	Description
Type	Rock Rip-Rap	Broken rock placed as continuous layer on slope
	Broken Concrete	Broken concrete either stacked or placed randomly
	Masonry/Concrete	Any stacked, mortared masonry structure or monolithic concrete structure
	Gabion	Rock-filled wire basket
	Sacrete	Concrete sacks placed along bank, cured in place
	Grouted Rock	Similar to rock rip-rap but sprayed with concrete grout
	Cribwall	Earth retaining structure formed of members running parallel to stream anchored into bank with other perpendicular members
	Wood Retaining Wall	Any wood structure that retains soil
	Biotechnical	Any revetment specifically incorporating vegetation for strength in the design
	Automobiles/waste	Old cars, tires, etc.
	Other	Self explanatory
Location	Left Bank	Revetment located on left bank (looking downstream)
	Right Bank	Revetment located on right bank (looking downstream)
Condition	1) Like New	Configuration likely similar to newly constructed condition
	2) Damaged, works	Parts of structure moved or damage by flow, but structure still protects bank
	3) Failing	Structure no longer provides significant protection from erosion
Riparian Habitat	Pools	Stream becomes significantly deeper and/or slower
	Instream cover	Debris/undercut bank/vegetation present below flow line
	Canopy	Stream shaded by veg that could be removed if site stabilized
(represents the type of features that could	Pools & Instream Cover	see above
potentially be changed	Pools & Canopy	see above
by a bank stabilization project at the site)	Instream Cover & Canopy	see above
Length (m)		Estimated length of failure. Used only for QC purposes.
Height (m)		Height of structure, estimated using surveying rod.
Upstream Condition	Stable, no threat	No visible reason to expect banks would begin eroding in future
	Eroding, threat	Upstream bank is beginning to cut around structure, potentially destabilizing it

Downstream Transition	Stable	No visible reason to expect banks would begin eroding in future
	Unstable this bank	Bank is currently eroding, cutting in around structure and/or work on structure could destabilize same bank just downstream
	Unstable opposite bank	Work on structure appears to have potential to destabilize opposite bank just downstream
	Unstable both banks	Work on structure appears to have potential to destabilize both banks just downstream
Photo Time		Time feature was recorded. Used to match with photo.

Significant Changes in Channel Grade (grade.shp)

Significant changes in channel grade are points in the stream bed, either natural or constructed, where the channel steepens significantly. In many cases, these were located where bedrock crosses the stream bed. In these cases, the feature was copied into the bedrock database, but the original feature was retained in the Significant Changes in Channel Grade database.

Table A-3. Change in Channel Grade Data Dictionary

Attribute	Possible Values	Description
Type	Bedrock Sill	Bedrock extends entirely across channel, preventing upstream bed degradation
	Concrete	Concrete extends entirely across channel, preventing upstream bed degradation
	Other	Other type of structure that permanently prevents degradation
Photo Time		Time feature was recorded. Used to match with photo.

Hydraulic Obstructions (Hyd_obst.shp)

Hydraulic obstructions are features that could potentially block part of the flow in the stream channel during a large storm. They were three types: woody debris, willow thickets, or other (usually gravel bars). A rough estimate as to the amount of banktop to banktop flow capacity they could reduce was made in the field by the data technicians. However, these estimates are intended only to help determine the relative importance of the features and should not be considered a definitive hydraulic conclusion.

Table A-4. Hydraulic Obstructions Data Dictionary

Attribute	Possible Values	Description
Type	Willows	Willows colonizing gravel bar reducing stream capacity
	Downed wood	Large woody debris directly reducing capacity or anchoring large gravel bar that reduces capacity
	Other	Any other feature that locally reduces flow capacity
% Capacity Obstructed		Visual estimate of cross sectional area below banktop obstructed by feature
Riparian Habitat	Pools	Stream becomes significantly deeper and/or slower
	Instream cover	Debris/undercut bank/vegetation present below flow line
	Canopy	Stream shaded by veg that could be removed if obstruction removed
(represents the type of features that could	Pools & Instream Cover	see above

potentially be changed	Pools & Canopy	see above
by removing the obstruction)	Instream Cover & Canopy	see above
Photo Time		Time feature was recorded. Used to match with photo.

Reach Characterization Site (strse.shp)

Reach characterization sites were locations in the stream system where the channel characteristics changed as one walked from upstream to downstream. The characteristics of the reach immediately upstream from the sampling point were recorded at the reach characterization sites. Perhaps the most useful piece of data recorded at reach characterization sites were the photographs taken at each location.

Table A-5. Reach Characterization Site Data Dictionary

Attribute	Possible Values	Description
Depositional Features	none	No evidence of long-term deposition in reach
	point bars	Reach characterized by active point bars on inside of meander bends
	mid-channel bars	Reach characterized by several mid-channel bars
	side bars	Reach characterized by bars next to bank but not necessarily on inside of meanders
	delta bars	Reach characterized by bars adjacent to tributaries
	multiple bar types	Combination of above
Main Channel “n”		Field estimate of mannings roughness of low flow channel (note: dropped from hydraulic analysis)
Overbank “n”		Field estimate of mannings roughness for area above low flow channel (note: dropped from hydraulic analysis)
Bar Vegetation	not applicable	No significant bars present in reach
	0-25%	Percentage estimate represents proportion of bars that are stabilized against
	25-50%	further mobilization by bar-top vegetation..
	50-75%	
	75-100%	
Bed Scour Evidence	None	A reach-wide estimate of the magnitude of incision that could has occurred historically
	<1 foot	since the first structures were constructed in the stream channel. Evidence includes
	1-3 feet	undercut revetments, walls, bridge abutments, pipes, etc.
	>3 feet	
Bed Composition	clay	Cohesive consolidated bed. Material can usually support human weight.
	silt	Fine unconsolidated material, often organic. Material often can not support h human wt
	sand	Median particle diameter <0.062 mm (below surface armor layer).
	gravel	Median particle diameter between 2 and 64 mm (below surface armor layer).
	cobbles	Median particle diameter between 64 and 256 mm (below surface armor layer).
	boulders	Median particle diameter above 256 mm..
	bedrock	Bedrock comprises more than 50% of bed.
	concrete	Concrete lining across entire channel.
	other	Any other bed material.

Photo time		Time feature was recorded. Used to match with photo.

Channel Classification (rosgen channel classification.shp)

Data collected for Reach Characterization Sites, discussed above, was used to classify channel reaches using the geomorphic stream classification system developed by Dave Rosgen (1996). The purpose of the classification is to identify stream segments that have similar geomorphic characteristics and consequently are likely to have similar response to future flood events.

Data in the channel classification database is based on the reach characterization site database, strse.shp. The only addition to this database was the actual stream classification according to the Rosgen system.

Channel centerlines developed for the database taken from the WMP HEC-RAS computer model, which developed them based on a LiDAR aerial survey. Where inventory data was collected outside the boundary of the HEC-RAS models (primarily on SLO creek upstream of Cuesta Park and in See Canyon), the stream centerline was digitized from on a scanned USGS quadrangle map.

The Rosgen system relies upon channel cross-sectional geometry, slope, planform, and substrate to classify a given stream reach. The WMP HEC-RAS hydraulic model was used for defining bankfull flow elevation and cross-sectional geometry, channel slope, and planform. Substate material was observed in the field (as part of data collection for strse.shp).

Table A-6. Reach Classification Data Dictionary

Attribute	Possible Values	Description
Rosgen_class	See (Rosgen, 1996)	Geomorphic classification of each channel reach based on channel geometry, slope, substrate, and planform. Geometry data was obtained from WMP HEC-RAS model. Substrate was observed in the field.
Depositional Features	Same as for strse.shp	See description for strse.shp.
Bar Vegetation	Same as for strse.shp	See description for strse.shp. significant bars present in reach
Bed Scour Evidence	Same as for strse.shp	See description for strse.shp.
Bed Composition	Same as for strse.shp	See description for strse.shp.
Photo time	Same as for strse.shp	See description for strse.shp.

Bridges (Bridges.shp)

Bridges were recorded where the channel passed under a roadway, whether through a true bridge or through a culvert. The only information recorded about bridges during the field inventory was a photograph.

Culvert Outfalls (stormdr.shp)

Culvert outfalls were recorded where ever they were visible from the stream. The type, size, and condition were recorded. Small pipes under six inches in diameter and underdrains were not inventoried due to time constraints. Also, since it is possible that certain culvert outfalls were not visible from the stream channel, the database provided here is likely incomplete.

Table A-7. Culvert Outfall Data Dictionary

Attribute	Possible Values	Description
Type	CMP	Corrugated Metal Pipe
	RCP	Reinforced Concrete Pipe
	Plastic	Any form of synthetic pipe material
	Box	Concrete Box Culvert
	Other	Other
Diameter (inches)		
Width (in, for box)		for box culverts
Height (in, for box)		for box culverts
Pipe Condition	Good	Pipe is likely to remain functional for the foreseeable future

	Average	Pipe is functional but has evidence of corrosion
	Poor	Pipe is corroded, possibly structurally unsound
Outfall Condition	No Erosion	Outfall uneroded
	Eroding	Outfall eroding, often with gully present
Photo Time		Time feature was recorded. Used to match with photo.

Visible Bedrock (bdrkline.shp and bdrkpts.shp)

Bedrock was an attribute that could be recorded as part of several kinds of features. For instance, it was possible to record bedrock at the toe of an eroding bank, on the bed of the channel in a channel reach, as a type of grade break, or as a separate feature. During post-processing, all features that contained bedrock were copied into a separate file (actually two files, one for point features and one for line features). Since the bedrock features were obtained from other features which are present in other inventory shape files, they often overlap the features they were derived from. This is a particularly large amount of overlap with the Change in Channel Grade database, since rock sills across the channel often result in abrupt changes in the channel profile. No attributes were coded into the GIS database for bedrock since it was generally compiled from other feature types.

References:

Rosgen, Dave, 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

A P P E N D I X B

Biological Resources Inventory

Prepared for:

Phase II Waterway Management Plan
for
San Luis Obispo County Zone 9
Flood Control and Water Conservation District
and
City of San Luis Obispo

Prepared by:

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Background Research/Studies

This Appendix describes the existing biological resources found within the study reaches of San Luis Obispo Creek, East Fork of San Luis Obispo Creek, Prefumo Creek, Stenner Creek, Brizziolari Creek and See Canyon Creek. The information in this Appendix is a compilation of botanical, wildlife, and fisheries data gathered during the Phase II creek inventory and from previous biological surveys along San Luis Obispo (SLO) Creek and its tributaries. The primary literature sources reviewed include:

- Biological resources assessment and impact analysis for the SLO Creek Water Reuse Project (Fugro West 1995);
- SLO Creek Restoration Plan (SLO Land Conservancy 1988);
- SLO Creek steelhead habitat inventory (Cleveland 1996);
- Stream Corridor Management Plan for SLO Creek Phase I Study Area (Questa 1997), and;
- SLO Creek Watershed Hydrologic Survey (SLOLC 1996).

Several Biological Assessments and Environmental Determinations for projects located along the SLO Creek riparian corridor were also reviewed.

Phase I Inventory Methods

Vegetative resources were mapped in Phase I using 21 vegetative series from the nomenclature of Sawyer and Keeler-Wolf (1995). The Reaches 8, 9, 10, 14, 17, and 19 of SLO Creek and tributaries were characterized in the Phase I study utilizing the following procedures:

- Extensive review of regional and local data sources and previous Environmental Determinations prepared for other proposed projects in the vicinity of SLO Creek and tributaries.
- Use of available aerial photography to identify limits of existing riparian vegetation.
- Ground-based confirmation of limits of riparian vegetation identified through aerial photographs.
- Canvassing of study areas during months of January and February of 1997 in order to characterize plant series' and enhancement opportunities.
- Visual estimation of cover values for herbaceous, shrub and tree layers.
- The analysis and compilation of existing data and field data, which consist of series-based maps of the riparian corridor (Plate III) and tables outlining cover values and enhancement opportunities (Appendix III).

Phase I creek reaches were inventoried for steelhead trout habitat following guidelines presented in the second edition of the *California Almonid Stream Habitat Restoration Manual (Flossi and Reynols, 1991).* The habitat types delineated were pools, riffles and flatwaters.

Phase II Inventory Methods

The baseline biological data for the Phase II study was inventoried in the field using a Trimble XR GPS unit. Creating an appropriate data dictionary was based upon review of the Phase I inventory and refined in consultation with Zone 9 and participating agencies. The resulting inventory included the following components: streams, pools, undercut banks, trees, shrubs, grasses, exotics, sensitive species and cultural resources. The methodology used in recording data for each of these resources is described below. It is important to note that although this has been termed a biological inventory, there are many components of the biological community of San Luis Obispo Creek and its tributaries that were not mapped or investigated within the scope of the Phase II study.

The data collected during field inventory was compiled in GIS (Geographic Information System) to be available for a variety of mapping and planning endeavors. The GIS data is available through a Cal Poly website at *http://midnight.calpoly.edu/gist/slo_creek* and through the City of San Luis Obispo Engineering Department.

Streams

Streams were recorded as line features using the GPS unit. The water edge at both banks was walked and recorded by the GPS. The field technician began by walking upstream along the left bank to collect the attributes (characteristics) of the stream channel. Walking upstream was required in order to more easily observe instream features as walking downstream would cause turbidity to impair visibility of the attributes. Attributes that were recorded in the field are as follows:

- Type (glide, riffle, or run)
- Substrate (silt/clay, sand, gravel, cobble, boulder, bedrock, or man-made)
- Gradient (low, high, or cascade)
- Depth (<0.5m, 0.5-1m, 1-2m, or >2m)

The line of the right bank was recorded while walking downstream. These two line features established a general width of the creek. The stream type observed in the field was based on the definitions described in the U.S. Forest Service's *Stream Habitat Classification and Inventory Procedures for Northern California, Fish Habitat Relationships Technical Bulletin, No. One (no date).*

Classifying substrate proved more subjective. Many sections of creek consisted of a mixed assortment of substrate. For the purposes of this inventory, the substrate recorded was the predominant type present. In many instances, silt covered the substrate. If silt caused the substrate to become more than 80% embedded the substrate was classified as silt/clay, otherwise it was classified according to the underlying substrate. Cobble was distinguished from gravel if the substrate was generally larger than 1 inch in diameter.

Stream gradient classification was also based on the above-mentioned manual.

Stream depth was estimated and generalized throughout the stream type. Often, mapping the stream required traversing under heavy riparian canopy that eliminated satellite reception

and disabled the GPS unit function for varying lengths of creek. Aerial photographs and field notes were used during such occurrences to provide a characterization of the stream.

Pools

Pools were recorded with the GPS unit as two point features. The first point was the downstream end of the pool, while the second point was recorded at the upstream end of the pool. As with the stream feature, pools were recorded while walking upstream in order to decrease the likelihood of silting the pool and impairing observation of the pool attributes. Pool attributes recorded in the field are as follows:

- Width
- Type (backwater, confluence, corner, dammed, lateral scour, mid-channel, plunge, pocket, or secondary channel)
- Substrate (clay, silt, sand, gravel, cobble, claystone, bedrock, or man-made)
- Depth (<0.5m, 0.5 - 1m, 1 – 2m, or >2m)
- Cause (bedrock, root wad, log, or man-made)
- Shade cover (80% +, 50-79%, 25-49%, or <25%)
- Emergent vegetation (yes or no)

The width of the pool was estimated in the field and not measured directly. The pool type observed in the field was based on the definitions described in the U.S. Forest Service's *Stream Habitat Classification and Inventory Procedures for Northern California.* Substrate found in the pools was evaluated in the same way that was described for streams, above.

The depth of the pools was also estimated and placed within one of the four depth ranges provided by the GPS data dictionary. The cause of the pools was also based on the Habitat Classification manual referred to above. The percentage of shade cover a pool had was estimated as the percentage of the pool under the canopy if looking straight down from directly above the pool. Emergent vegetation was noted simply as present or absent.

Photographs were taken of most pools. Every attempt was made to take the photographs from the downstream end of the pool. However, when vegetation or lighting obstructed the view of the pool an alternative angle was used. Accuracy was diminished in some instances by the inability to access GPS satellites signals due to the thick canopy. Aerial photographs were used in the field to help accurately fill in the gaps in GPS data.

Undercut Banks

Undercut banks were also recorded as two points representing the downstream and upstream ends of the undercut bank.

Trees

Tree species were recorded as area features with the GPS unit. The field technician recorded tree features by walking around individuals and groups of trees. In locations where the technician was unable to walk around the tree area, aerial photographs were used to identify the extent of the area during post-processing. Accuracy was diminished in some instances by the inability to access signals from satellites due to the thick canopy. Aerial

photographs were used in the field to help accurately fill in the gaps in GPS data. Attributes of the tree features recorded in the field are as follows:

- Type (arroyo willow, black cottonwood, box elder, black walnut, coast live oak, California sycamore, eucalyptus, Hinds walnut, Monterey cypress, Monterey pine, mixed willow, pepper tree, California bay, or ornamental)
- Percent cover (80% +, 50-79%, 25-49%, or <25%).

The species specifically identified by type in the GPS unit were chosen for consistency with the Phase I inventory. The Phase II tree inventory differs from that of Phase I in that tree features were not recorded as tree "series", but as individuals and stands of trees. The ornamental option was added to identify tree species, other than those specifically named that are horticultural varieties not native to the watershed.

Shrubs

Shrubs were recorded as area features with the GPS unit. The field technician recorded shrub features by walking around individuals and groups of shrubs. In locations where the technician was unable to walk around the shrub area, aerial photographs were used to identify the extent of the area during post-processing. Attributes of the shrub features recorded in the field are as follows:

- Type (California sagebrush, coyote bush, other shrub, or ornamental
- Other ID (type in the shrub species)
- Percent cover (80% +, 50-79%, 25-49%, or <25%)

The ornamental type was added to identify shrub species that are horticultural varieties not native to the watershed. Accuracy was diminished in some instances by the inability to access signals from satellites due to the thick canopy. Aerial photographs were used in the field to help accurately fill in the gaps in GPS data.

Grasses

Grasses were recorded as area features with the GPS unit. Attributes of the grass features recorded in the field are as follows:

- Type (perennial-introduced, perennial-native, serpentine, annual-introduced, annual-native, crops, and agricultural use)
- Percent cover (80% +, 50-79%, 25-49%, or <25%)

Grass areas were only recorded when grass was the primary vegetation type of an area or when an area contained a native grass component. Some areas within the watershed exhibit crop or agricultural use to the edge of the stream. For this reason, crops and agricultural use were added to the collection dictionary. Kikuyu grass was recorded as an exotic species due to its aggressive nature and the need to address its eradication.

Exotic Species

Exotic species were recorded as point and line features using the GPS unit. Isolated individual occurrences were typically recorded as point features, whereas large areas of exotics were recorded as lines showing the extent of coverage. Attributes of the exotic species recorded in the field are as follows:

- Type (Arundo, cape ivy, castor bean, or other)
- Other ID (exotic species name)
- Percent cover (80% +, 50-79%, 25-49%, or <25%)

Arundo, cape ivy, and castor bean are specifically addressed because they were identified as the primary exotic species in the watershed. However, the "Other ID" field allowed us to type in other exotic species that occurred throughout the watershed. Typically, exotic species that have groundcover habits, such as cape ivy, Vinca, kikuyu grass and English ivy, were recorded as line features. The length of the line delineates their upstream and downstream extents.

Special-status Species

A few of the special-status species in the watershed were specifically included in the inventory. These included the California red-legged frog, southern steelhead, southwestern pond turtle, two-striped garter snake, tidewater goby, and southwestern willow flycatcher. Sightings of these species were recorded as point features when observed. The number individuals of each species observed at any particular point was recorded. Age class was also noted for red-legged frog and steelhead. The only special-status animal species observed during the inventory were southwestern pond turtle and southern steelhead.

Cultural Resources

Cultural resources were recorded as point features with the GPS unit. This feature was included in the event that any obvious signs of cultural or historic resources were encountered. This inventory effort was not intended to serve as a comprehensive survey of the riparian corridor. The types of cultural resources in the data dictionary were as follows:

- shell midden,
- dark-oily soil,
- modified chert or obsidian
- bones, rock mortar, groundstone
- homeless camp
- building remains

The only type from this list that was observed and recorded was homeless camp. Homeless camp was included at the request of the City.

Habitats - Vegetation Classification Overview

Riparian vegetation within the San Luis Obispo Creek watershed was classified and mapped during the Phase I inventory (Questa 1997) using the vegetative series nomenclature of Sawyer and Keeler-Wolf (1995). In total, 21 vegetative series were identified during the Phase I effort. The following discussion approaches classification of vegetation in a somewhat different manner, using the classification system authored by the California

Department of Fish and Game (R. Holland 1986) and the system used by the USFWS (Cowardin et al. 1979). Both of these classification systems are more broad-brushed than Sawyer and Keeler-Wolf, resulting in fewer classified community types. Using these two classification references, six habitat types were identified in association with the San Luis Obispo Creek riparian corridor, including: 1) Riverine, 2) Freshwater Marsh, 3) Riparian Forest, 4) Riparian Scrub, 5) Southern Coastal Salt Marsh, and 6) Ruderal/Disturbed. Descriptions of these habitats, as found in the SLO Creek watershed, are provided below.

Habitat Types

Riverine Habitat

The streambed areas of San Luis Obispo Creek and its major tributaries are classified as Riverine habitat. Riverine habitat includes both the active flowing channel and associated gravel/sand floodplain areas. Seasonally, this habitat type supports emergent hydrophytes (water loving plants) such as watercress (*Rorippa nasturtium-aquaticum*), bulrush (*Scirpus* spp.), and cattail (*Typha latifolia*). Such vegetated areas are often classified as jurisdictional wetlands and are regulated by the U.S. Army Corps of Engineers. Upper watershed areas have relatively steep stream gradients and higher flow velocities, while lower riverine habitats have slower water velocities and well-developed floodplains. Substrate within this habitat type is typically variable, and may consist of bedrock, clay, cobbles, gravels, and sand.

Freshwater Marsh Habitat

Freshwater marsh communities typically occur in nutrient-rich mineral soils that are saturated throughout most of the year. These communities are found in locations containing slow-moving or stagnant shallow water and a high water table (R. Holland 1986). Such sites commonly occur around springs, seeps, stream channels, and depressional areas that accumulate runoff from surrounding areas. Standing water does not have to be present throughout the entire year, since the water table is so close to the soil surface that it can be tapped in the dry season by hydrophytic plants.

Plant species diversity within freshwater marsh areas of the watershed is moderate to high, and this habitat type typically exhibits dense vegetative coverage. Various plant species observed in areas of freshwater marsh containing saturated soils or surface water include arroyo willow (*Salix lasiolepis*), cattail, barnyard grass (*Echinocloa crus-galli*), water smartweed (*Polygonum punctatum*), California bulrush (*Scirpus californicus*), saltgrass (*Distichlis spicata*), brown-headed rush (*Juncus phaeocephalus*), umbrella sedge (*Cyperus eragrostis*), watercress, spikerush (*Eleocharis macrostachya*), seep monkeyflower (*Mimulus guttatus*), and duckweed (*Lemna* spp.). Additional species typical of the study areas include mugwort (*Artemisia douglasiana*), horsetail and scouring rush (*Equisetum* spp.), and stinging nettle (*Urtica* spp.). A good example of freshwater marsh habitat may be seen within the lower reaches of the East Fork of San Luis Obispo Creek (Morro Group 2001a).

Riparian Forest Habitat

Riparian forest habitat consists of moderate to dense closed-canopy broadleaf vegetation that closely follows streambank contours. Dominant species and canopy density varies with elevation and topography along the riparian corridor. The overall structure of the riparian

community found within the study areas is composed of an assemblage of native and introduced tree species. Species characteristic of the overstory layer include endemic species such as tree and shrub forms of willows (*Salix lasiolepis*, *S. lucida* ssp. *lasiandra*, and *S. laevigata*), California sycamore (*Platanus racemosa*), black walnut (*Juglans hindsii* ssp. *hindsii*), coast live oak (*Quercus agrifolia*), California bay (*Umbellularia californica*), Fremont cottonwood (*Populus fremontii*), black cottonwood (*P. balsamifera* ssp. *trichocarpa*), Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus marocarpa*), white alder (*Alnus rhombifolia*), big-leaf maple (*Acer macrophyllum*), and box elder (*Acer negundo* ssp. *californica*). Non-native, naturally reproducing trees commonly found within the watershed include eucalyptus (*Eucalyptus* spp.), black locust (*Robina pseudoacacia*), pepper tree (*Schinus molle*), phoenix palm (*Phoenix canariensis*), and tree of heaven (*Ailanthus altissima*). Urban areas of the watershed typically also contain a large number of ornamental tree species. This is the dominant streamside habitat type within the SLO Creek watershed at those locations not subject to urban encroachment or severe cattle grazing. Good examples of riparian forest habitat are evident on the upper SLO Creek mainstem near Cuesta Park.

Riparian Scrub Habitat

Riparian scrub communities are characterized as scrubby streamside thickets dominated by willows that occur along frequently inundated lands along perennial and intermittent rivers and streams, or in areas where the water table is at or near the ground surface (R. Holland 1986). These communities are considered sensitive by CDFG and frequently qualify as wetland, thereby also falling under Corps jurisdiction. Riparian scrub is distributed throughout the San Luis Obispo Creek watershed). This community type typically occurs adjacent to flowing stream channels or seasonally flooded arroyos, or in depressional areas located close to ground water. The overstory of the riparian scrub community is typically dominated by dense arroyo willow. Characteristic native shrub species include coffeeberry (*Rhamnus californica*), wild rose (*Rosa californica*), toyon (*Heteromeles arbutifolia*), elderberry (*Sambucus mexicana*), poison oak (*Toxicodendron diversilobium*), virgin's bower (*Clematis ligustifolia*), coyote brush (*Baccharis pilularis*), mule fat (*B. salicifolia*), California sagebrush (*Artemisia californica*), fuchsia-flowered gooseberry (*Ribes speciosum*) and blackberry (*Rubus ursinus*).

Exotic shrub species found within the watershed include castor bean (*Ricinus communis*), giant reed (*Arundo donax*), tree tobacco (*Nicotiana glauca*), Scotch broom (*Cytisus scoparius*), cultivated Himilayan blackberry (*Rubus discolor*), cocklebur (*Xanthium* spp.), Cape ivy (*Delairea odorata*), poison hemlock (*Conium maculatum*), sweet fennel (*Foeniculum vulgare*), and Japanese honeysuckle (*Lonicera japonica*). Riparian scrub communities often are dominated by hydrophytes and as such, may be classified as jurisdictional wetland habitat regulated by the Corps. This habitat type is common within the SLO Creek watershed, with good examples evident on the SLO Creek mainstem near the South Higuera Street bridge (Morro Group 2001b).

Southern Coastal Salt Marsh

This community typically occurs near the confluence of creeks and seawater, in areas protected from wave action. These habitats typically exhibit a characteristic zonation of plant types based on depth and duration of inundation by salt water. Coastal salt marsh vegetation consists primarily of low-growing, salt tolerant, herbaceous perennial plants. Species consist of perennial, emergent, herbaceous monocots, including sedges (*Carex spp*), saltgrass, rushes (*Juncus* spp.), frankenia (*Frankenia grandiflora*), fleshy jaumea (*Jaumea carnosa*), pickleweed (*Salicornia virginica*), and cattails. Southern coastal salt marsh may be classified as jurisdictional wetland habitat regulated by the Corps. This habitat type occurs patchily within the tidally influenced portion of SLO Creek below the Marre Dam.

Ruderal/Disturbed Habitat

Ruderal vegetation (disturbed habitat) is found in areas that have been significantly altered by agriculture, construction, or other land-clearing activities. Ruderal habitats often occur in abandoned agricultural fields, along roadsides, and in other areas experiencing severe ground surface disturbance. Ruderal areas are present throughout the lower portions of the watershed, particularly in urbanized areas. Representative species at these locations include summer mustard (*Hirschfeldia incana*), poison hemlock, kikuyu grass (*Pennisetum clandestinum*), *Vinca*, Italian thistle (*Carduus pycnocephalus*), giant reed, bristly ox-tongue (*Picris echioides)*, and castor bean. Exotic species commonly found within the herbaceous layer consist of periwinkle (*Vinca major*), Cape ivy, bristly ox-tongue, English ivy (*Hedera helix*), Bermuda buttercup (*Oxalis pes-caprae*), rabbitsfoot grass (*Polypogon monspeliensis*), and Bermuda grass (*Cynodon dactylon*). These species often intergrade with Riparian Scrub habitat.

Extensive areas containing exotic species are present throughout the watershed. Generally, these plants are ornamental, agricultural or weedy species that have escaped and become naturalized. These invasive plant species often have no natural predator and therefore have the ability to out compete native species for valuable habitat. This displacement of native plant species degrades overall riparian habitat quality. Tree species that negatively impact native habitat include eucalyptus, black locust, and tree of heaven. Shrubs include giant reed, castor bean, sweet fennel, poison hemlock, and Scotch broom. Herbs include Cape ivy, periwinkle, bristly ox-tongue, and Japanese honeysuckle.

Sensitive Communities and Species

Sensitive species are plants and animals that are either listed as endangered or threatened under the Federal or California Endangered Species Acts, rare under the California Native Plant Protection Act, or considered to be rare (but not formally listed) by resource agencies, professional organizations (e.g., Audubon Society, CNPS, The Wildlife Society), and the scientific community. For the purposes of this project, sensitive species are defined in Appendix A. Sensitive communities are those habitats or plant associations considered rare by the CDFG (R. Holland 1986).

The following sections address those sensitive communities and species known from, or with a reasonable chance to occur within, the SLO Creek watershed. The primary source consulted was the California Natural Diversity Database (NDDB) for the San Luis Obispo (NDDB 2000a), Pismo Beach (NDDB 2000b), and Lopez Mountain (NDDB 2001)

quadrangles. Other sources include the documents listed at the beginning this Appendix B. Table B-1 identifies the name and legal status of sensitive taxa revealed during this search, and a narrative discussion follows.

Sensitive Plant Communities

Two rare plant communities (R. Holland 1986) were mapped by the NDDB (2000a, 2000b) within the SLO Creek watershed, including Coastal and Valley Freshwater Marsh, and Serpentine Bunchgrass. Three addition CDFG rare habitats are also present within the watershed. These include Northern Coastal Salt Marsh, Central Coast Arroyo Willow Riparian Forest, and Central Coast Riparian Scrub. All of these habitats are recognized by the CDFG as "rare" based on past and present habitat degradation and land conversion practices.

Northern Coastal Salt Marsh

Northern Coastal Salt Marsh habitat is defined by the CDFG (R. Holland 1986) as those salt marsh habitats ranging from the Oregon border southward to Point Conception, Santa Barbara County, California. This habitat type is highly productive, and is typically composed of herbaceous, salt-tolerant species. Regular tidal inundation is a physical requirement of this habitat type, which has been reduced in distribution historically by intensive seaport development, particularly in Humboldt Bay, Tomales Bay, Elkhorn Slough, Morro Bay, and San Francisco Bay (R. Holland 1986). Northern Coastal Salt Marsh habitat is restricted to isolated patches and narrow strips within the lower portions of Reach 1 of SLO Creek. Representative species within Reach 1 include pickleweed (*Salicornia virginica*) and saltgrass (*Distichlis spicata*).

Central Coast Arroyo Willow Riparian Forest

This habitat type is typified by dense, low, closed-canopy, broadleafed, winter deciduous riparian forests dominated by arroyo willow (*Salix lasiolepis*). Other willow species such as red willow (*S. laevigata*) and yellow willow (*S. lasiandra*) typically are found in association with this habitat type. Central Coast Arroyo Willow Riparian Forest (CCAWRF) habitat is distributed along low-gradient stream corridors from coastal Monterey to Santa Barbara. Within the SLO Creek watershed, this habitat type is widely distributed through most reaches of the SLO Creek mainstem, and within most SLO Creek tributaries. Within Reach 1, tidal influences have limited the distribution of CCAWRF habitat to the area near Marre Dam.

Central Coast Riparian Scrub

Similar to CCAWRF habitat (previous section), Central Coast Riparian Scrub (CCRS) habitat is widely distributed within the SLO Creek watershed, and is ubiquitous within all SLO Creek tributaries and mainstem reaches other than Reach 1. This habitat generally consists of a scrubby streamside thicket dominated by any of several willow species. R. Holland (1986) considers CCRS habitat an early seral community, later developing to riparian forest habitats. Characteristic species include willows (*Salix* spp.) and coyote brush (*Baccharis pilularis*).

Coastal and Valley Freshwater Marsh

Coastal and Valley Freshwater Marsh (CVFWM) habitat is typically dominated by perennial, emergent monocots, often forming completely closed canopies. This habitat type is characteristic of permanently flooded freshwater sites without significant current. The NDDB (2000a) maps CVFWM habitat in association with Laguna Lake within the Prefumo Creek sub-watershed. An expansive area of CVFWM habitat exists near the lower portions of the East Fork near its confluence with SLO Creek, with hydrology supplied by the East Fork and several groundwater seeps flowing downward from the serpentine ridge south of confluence area (Morro Group 2000a). The CDFG (R. Holland 1986) considers CVFWM habitat as sensitive in California primarily due to farmland conversion and other large-scale mechanisms of habitat loss.

Serpentine Bunchgrass

Serpentine Bunchgrass is characteristically open grassland dominated by native, perennial bunchgrasses with typically low vegetative cover. Within the study area, the dominant species is purple needle-grass (*Nassella pulchra*). The NDDB (2000a) maps this community type above the Cal Poly campus in association with Brizziolari Creek. A good example of serpentine bunchgrass habitat can be seen at the base of the serpentine outcrop immediately south of the confluence of the East Fork with SLO Creek (Morro Group 2000a).

Sensitive Plant Species

Thirteen sensitive plant species are known to be present within or adjacent to riparian areas of the watershed (refer to Table B-1). Most of the species listed are considered serpentine associates or serpentine endemics. Individual species accounts, described below, are based largely on Skinner and Pavlik (1994), Hoover (1970), and Hickman (1993). Occurrence data are primarily derived from the NDDB and from the Cal Flora Occurrence Database (www.calflora.org), unless noted otherwise in text.

TABLE B-1
Sensitive Vegetation with the Potential to Occur in the San Luis Obispo Creek Riparian Corridor

Scientific Name	Common Name	Legal Status Federal/State/CNPS/RED
Communities		
	Northern Coastal Salt Marsh	CDFG Rare
	Central Coast Arroyo Willow Riparian	CDFG Rare
	Central Coast Riparian Scrub	CDFG Rare
	Coastal/Valley Freshwater Marsh	CDFG Rare
	Serpentine Bunchgrass	CDFG Rare
Plants		
Arctostaphylos pechoensis	Pecho manzanita	FSC/--/1B/2-2-3
Arctostaphylos wellsii	Wells's manzanita	--/--/1B/2-3-3
Calochortus obispoensis	San Luis mariposa lily	--/--/1B/2-2-3
Carex obispoensis	San Luis Obispo sedge	--/--/1B/2-2-3
Chorizanthe brewerii	Brewer's spineflower	--/--/1B/3-1-3
Cirsium fontinale var. *obispoense*	Chorro Creek bog thistle	FE/SE/1B/3-2-3
Dudleya abramsii ssp. *bettinae*	San Luis Obispo serpentine dudleya	FSC/--/1B/3-2-3
Dudleya abramsii ssp. *murina*	San Luis Obispo dudleya	--/--/1B/2-1-3
Centromadia parryi ssp. *congdonii*	Congdon's tarplant	FSC/--/1B/3-3-3
Layia jonesii	Jones's layia	FSC/--/1B/3-2-3
Sanicula maritima	adobe sanicle	FSC/SR/1B/3-3-3
Senecio aphanactis	rayless ragwort	--/--/2/3-2-1
Streptanthus albidus var. *peramoenus*	most beautiful jewel-flower	FSC/--/1B/2-2-3
FE: federally endangered **FSC**: federal species of concern **SE**: California endangered **SR**: California rare *California Native Plant Society (CNPS):* **List 1B** = rare in California and elsewhere. **List 2** = rare in California	*CNPS Rare-Endangerment-Distribution*: **Rare**: 1 = rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time; 2) distributed in a limited number of occurrences, occasionally more if each occurrence is small; 3) distributed in one to several highly restricted occurrences, or present in such small numbers that it is seldom reported.	CNPS R-E-D (continued): **Endangerment**: 1) not endangered; 2) endangered in a portion of its range; 3) endangered throughout a portion of its range. **Distribution**: 1) more or less widespread outside California; 2) rare outside California; 3) endemic to California.

Table B-2 presents the occurrences of sensitive habitats and plant species in the study reaches. Central coast arroyo willow riparian forest and Central Coast riparian scrub, both sensitive habitats are prevalent throughout all of the creek reaches. The potential for occurrence of a sensitive plant species is indicated where reach conditions/habitat are particularly suitable for that species.

TABLE B-2
Sensitive Habitats & Plant Species Occurring in the Study Reaches

Sensitive Habitats	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Reach 15	Reach 16	Reach 17	Reach 18	Reach 19	Reach 20	Reach 21	Reach 22	Reach 23	Reach 24	Old Garden Creek
Northern Coastal Salt Marsh	x																								
Central Coast Arroyo Willow Riparian Forest	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
Central Coast Riparian Scrub	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Coastal and Valley Freshwater Marsh															x	x						x			
Serpentine Bunchgrass																x									
Sensitive Plant Species																									
Pecho manzanita		p																					p		
Wells's manzanita	x	x																							
San Luis mariposa lily													p	x									p		
San Luis Obispo sedge															p			p							
Brewer's spineflower													x	x								x	x		
Chorro Creek bog thistle																x									
San Luis Obispo serpentine dudleya																x									
San Luis Obispo dudleya									x																
Congdon's tarplant																									
Jones's layia						x	x									x	x	x							
adobe sanicle																	x	x							
rayless ragwort									x				x	x											
most beautiful jewel-flower											x	x	x	x									x		

x indicates record/sighting in CNDDB
p indicates the potential to occur in this reach

Pecho Manzanita (*Arctostaphylos pechoensis*)
Pecho manzanita is known from the western portion of the Santa Lucia Range, from Coon Creek, and from See Canyon. This species is endemic to siliceous shale of San Luis Obispo County, occurring primarily in closed cone coniferous forests, chaparral, and coastal scrub communities. The typical flowering period for this species is January through March. Pecho manzanita is a federal special concern species that is considered very rare (RED 2-2-3) by the CNPS. The NDDB (2000a, 2000b) maps pecho manzanita along Prefumo Canyon Road, and within the San Miguelito Creek drainage between See Canyon and Davis Canyon.

Wells's Manzanita (*Arctostaphylos wellsii*)
This San Luis Obispo County endemic shrub is included on CNPS List 1B, but does not currently have any state or federal status. It has an R-E-D code of 2-3-3 (very rare). Wells's manzanita occurs in the San Luis Range from upper Coon Creek in Montana de Oro State Park to Arroyo Grande and Nipomo. The main populations of this species are found in the sandstone hills between the San Luis Valley and the ocean. The NDDB (2000b) maps this species along Avila Beach Road, near Sycamore Mineral Springs.

San Luis Mariposa Lily (*Calochortus obispoensis*)
San Luis mariposa lily is a perennial, herbaceous member of the lily family that is endemic to San Luis Obispo County, ranging from Cuesta Pass south to Arroyo Grande. The San Luis mariposa lily is known from chaparral, coastal scrub, grassland, and freshwater seep habitats of dry, serpentine soils. This species blooms from May to July. The California Native Plant Society (CNPS) assigns this species to List 1B, 2-2-3 R-E-D. The NDDB and Cal Flora list 48 historical occurrences of this species, with the majority located on west Cuesta Ridge, upper SLO Creek near Reservoir Canyon, upper Stenner Creek, and upper Chorro Creek. An additional occurrence is mapped in the Froom Creek region.

San Luis Obispo Sedge (*Carex obispoensis*)
San Luis Obispo sedge is a perennial (rhizomatous) herb that is native and endemic to California. This species chiefly occurs on steep, serpentine-derived hillsides in association with chaparral and coastal sage scrub habitats, and flowers from April to June. The CNPS considers this species as rare (List 1B, 2-2-3 R-E-D). Cal Flora lists 34 historical occurrences of this species, with the majority of these from west Cuesta Ridge, San Simeon, Cerro Alto, and the Prefumo Creek region. In addition, the NDDB (2000a) maps this species near the headwaters of Stenner Creek. Suitable habitat for this species is present within areas of the watershed containing serpentine soils.

Brewer's Spineflower (*Chorizanthe brewerii*)
Brewer's spineflower occurs in closed-cone coniferous forest, chaparral, cismontane woodland, and coastal scrub habitats, primarily on serpentinite substrates. The NDDB and Cal Flora list 48 historical occurrences of this species, with the majority located on west Cuesta Ridge, upper SLO Creek in Reservoir Canyon, Stenner

Creek, and Chorro Creek. Suitable habitat for this species is present within areas of the watershed containing serpentine soils. The CNPS considers this species as rare (List 1B, 3-1-3 R-E-D).

Chorro Creek Bog Thistle (*Cirsium fontinale* var. *obispoense*)
The Chorro Creek bog thistle, a San Luis Obispo County endemic, occurs primarily in association with serpentine seeps located in chaparral and cismontane woodland communities. This fairly tall (to 6.5 feet) perennial herb flowers primarily from February to July. It is ranked by CNPS as extremely rare (List 1B, 3-2-3 R-E-D). It is listed as both State and Federally Endangered. Chorro Creek bog thistle is mapped by the NDDB and Cal Flora as occurring along Prefumo Creek. Fugro (1995) reports occurrences of this species from Laguna Lake and Froom Creek.

San Luis Obispo Serpentine Dudleya (*Dudleya abramsii* ssp. *bettinae*)
San Luis Obispo serpentine dudleya is a succulent, perennial herb and a San Luis Obispo County endemic that is distributed within the San Luis Obispo, Morro Bay North, Cayucos, and Morro Bay South quadrangles. It is typically associated with coastal scrub and valley foothill grassland communities on serpentine soils, and blooms from May to July. It is ranked by the CNPS as extremely rare (List 1B, 3-2-3 R-E-D), and is listed by the federal government as a Species of Concern. Cal Flora catalogs 17 historical occurrences of this species, with most from Morro Bay and Cayucos. However, an occurrence was mapped in 1994 on “glider hill”, a serpentine outcropping directly behind (west of) Madonna Inn.

San Luis Obispo Dudleya (*Dudleya abramsii* ssp. *murina*)
San Luis Obispo dudleya flowers from May to June, and is a serpentine endemic to California that is typically found in chaparral and foothill woodland habitats. It is considered rare by the CNPS (List 1B, 2-1-3 R-E-D). Similar to *D. a. bettinae*, San Luis Obispo dudleya is not mapped on the NDDB (2000b) Pismo Beach quadrangle. Cal Flora catalogs 10 historical occurrences of this species, with most from Cuesta Park (north San Luis Obispo City), and a single occurrence on Cerro San Luis in 1950.

Congdon’s Tarplant (*Centromadia parryi* ssp. *congdonii*)
Congdon’s tarplant is endemic to California, occurring primarily within annual grassland habitats containing alkaline soils. Throughout San Luis Obispo County this species has been documented within low valleys located just west of the City of San Luis Obispo (Hoover 1970). This annual herb flowers from June through November. Congdon’s tarplant is a federal special concern species considered by the CNPS as extremely rare (RED 3-3-3). The NDDB (2000a) maps this species as occurring near Laguna Lake.

Jones’s Layia (*Layia jonesii*)
Jones’s layia is an annual herb found on serpentine or clay-based chaparral and valley grassland habitats. Within San Luis Obispo County, this species is known to range primarily from the Cayucos area south to San Luis Obispo. It is a California endemic, with flowering generally occurring in March to May. Jones’s layia is a

Federal Species of Special Concern, and is considered extremely rare by the CNPS (List 1B, 3-2-3 R-E-D). Cal Flora maps 33 occurrences throughout San Luis Obispo City and Morro Bay. Particularly, occurrences are mapped along south Higuera Street and near Laguna Lake.

Adobe Sanicle (*Sanicula maritima*)
Adobe sanicle is a San Luis Obispo County endemic. It is a federal concern and state rare species considered by the CNPS as extremely rare (3-3-3). Adobe sanicle is typically restricted to highly localized, seasonally wet areas located near the coast, and is generally found in association with grassland communities. The NDDB (2000a) maps this species on the low hills and valleys located west of San Luis Obispo City, and specifically, near Laguna Lake.

Rayless Ragwort (*Senecio aphanactis*)
Rayless ragwort is an annual herb that occurs in cismontane woodland and coastal scrub habitats, on alkaline soils (Skinner and Pavlik 1994). The typical flowering period for this species is from January through April. The NDDB (2000a) documents this species as occurring just east of the City of San Luis Obispo near Highway 101, in the vicinity of Madonna Road, and near the headwaters of SLO Creek. The CNPS considers this species as extremely rare (RED 3-2-1).

Most Beautiful Jewel-flower (*Streptanthus albidus* ssp. *peramoenus*)
Most beautiful jewel-flower is an annual herb that occurs in chaparral and grassland habitats, primarily on serpentine substrates (Skinner and Pavlik 1994). This species typically blooms from April through June. The California Native Plant Society (CNPS) assigns this species to List 1B, 2-2-3 R-E-D. The NDDB and Cal Flora document 22 historical occurrences throughout San Luis Obispo County, including Brizziolari, Stenner, Prefumo, and SLO creeks.

Sensitive Wildlife Species

The NDDB (2000a, 2000b, 2001) and environmental documents prepared within the SLO Creek watershed indicate the occurrence, or the reasonable potential for occurrence, of 13 sensitive animal species within the study area (Table B-3). These include: Cooper's hawk (*Accipiter cooperi*); pallid bat (*Antrozous pallidus*); southwestern pond turtle (*Clemmys marmorata pallida*); monarch butterfly (*Danaus plexippus*); yellow warbler (*Dendroica petechia*); willow flycatcher (*Empidonax traillii*); tidewater goby (*Eucyclogobius newberryi*); yellow-breasted chat (*Icteria virens*); southern steelhead trout (*Oncorhynchus mykiss irideus*); California red-legged frog (*Rana aurora draytonii*); California spotted owl (*Strix occidentalis* ssp. *occidentalis*; Coast Range newt (*Taricha torosa torosa*); and two-striped garter snake (*Thamnophis hammondii*). Known occurrences of these species, and the potential for occurrence by reach, are summarized within Table B-4. The potential for occurrence of a particular species noted within Table B-4 was based on the presence of suitable habitat, as defined by Burt and Grossenheider (1976), Remsen (1978), Robbins et al. (1983), and Zeiner at al. (1990). Individual species accounts, described below, are based on the same authoritative sources unless noted otherwise.

TABLE B-3
Sensitive Wildlife Species with the potential to occur
In the SLO Creek Watershed

Scientific Name	Common Name	Legal Status[a] Federal/State/CDFG
Accipiter cooperi	Cooper's hawk (nesting)	--/--/CSC
Antrozous pallidus	pallid bat	--/--/CSC
Clemmys marmorata pallida	southwestern pond turtle	FSC/--/CSC,P
Danaus plexippus	monarch butterfly (wintering)	--/--/*
Dendroica petechia	yellow warbler (nesting)	--/--/CSC
Empidonax traillii	willow flycatcher (nesting)	--/SE/--
Eucyclogobius newberryi	tidewater goby	FE/--/CSC,P
Icteria virens	yellow-breasted chat (nesting)	--/--/CSC
Oncorhynchus mykiss irideus	southern steelhead trout**	FT/--/CSC
Rana aurora draytonii	California red-legged frog	FT/--/CSC,P
Strix occidentalis	California spotted owl	FSC/--/CSC
Taricha torosa torosa	Coast Range newt	--/--/CSC
Thamnophis hammondii	two-striped garter snake	--/--/CSC,P

FE: Federally Endangered
FT: Federally Threatened
FSC: Federal Special Concern
SE: State Endangered
CSC: California Special Concern
P: CDFG Protected

*Restricted range in California

**south/central evolutionary significant unit (ESU)

Table B-4 presents the occurrences of sensitive wildlife species in the study reaches. The potential for occurrence of a sensitive wildlife species is indicated where reach habitat is available for that species.

TABLE B-4
Occurrence of Sensitive Wildlife Species by Study Reach

Sensitive Wildlife	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Reach 15	Reach 16	Reach 17	Reach 18	Reach 19	Reach 20	Reach 21	Reach 22	Reach 23	Reach 24	Old Garden Creek
southern steelhead	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	p	p	x	x	x	x	x	x	x
southwestern pond turtle	p	x	x	p	p	p	x	p	p			p	p	p	x	p	p	p	p	p	p	p	x		p
monarch butterfly	p	p				p	p	p	p	x	p	p	p	p	p	p		x	p	p	p	p	p		
tidewater goby	x																								
two-striped garter snake																x									
pallid bat	x					x	x			p	x	p	p			x									
California red-legged frog	x													x			x								
Coast range newt													x	x										p	p
yellow warbler	p	p	p	p	p	p	p							p	p	p		p				p		p	
yellow-breasted chat	p	p	p	p	p	p	p							p	p	p		p				p		p	
Cooper's hawk	p	p	p	p	p	p	p							p	p	p		p				p		p	
California spotted owl																								x	
willow flycatcher	p	p	p	p	p	p	p							p	p	p		p				p		p	

x indicates record/sighting in CNDDB
0 indicates an actual sighting during Morro Group Phase II GPS data collection
p indicates the potential to occur in this reach (see text for rationale)

Cooper's Hawk (*Accipter cooperi*)
Cooper's hawk is a fairly large accipter hawk that ranges throughout the United States and is widely distributed throughout California. This species is a resident of San Luis Obispo County, nesting and foraging in and near deciduous riparian areas. Cooper's hawk is rarely found in areas without dense tree stands or patchy woodland habitat. Breeding occurs March to August, peaking May to July. Incubation lasts about 36 days, and young are independent eight weeks thereafter (Baicich and Harrision 1997). California considers Cooper's hawk a Species of Special Concern, based on a reduction in breeding numbers in recent years. These reductions are reportedly due to destruction of lowland riparian habitat, and direct/indirect human disturbance at nest sites. Suitable habitat is present throughout the SLO Creek watershed where dense, relatively undisturbed riparian forest habitat persists.

Pallid Bat (*Antrozous pallidus*)
The pallid bat is a locally common species of low elevations in California that is distributed throughout the western and southwestern United States, southward into Mexico. In California, this species is found statewide except for higher elevations of the Cascade and Sierra Nevada ranges. Pallid bats establish day roosts in caves,

crevices, mines, and occasionally in hollow trees and buildings. Day roosts are selected in locations that protect pallid bats from high temperatures. Night roosts are often in more open sites such as porches and open buildings. This species mates from October to February, with a litter of two pups (typically) born during April through July (peaking May through June). Young are weaned in approximately seven weeks, and are flying freely by July to August. Pallid bats are very sensitive to disturbance of roosting sites, as such sites are important for metabolic economy, juvenile growth, and consumption of prey. California considers pallid bat a Species of Special Concern. Several bridges over SLO Creek are known to support day and/or night roosting pallid bats (Morro Group 1998, 2001b).

Southwestern Pond Turtle (*Clemmys marmorata pallida*)

The southwestern pond turtle (SWPT) ranges discontinuously from Monterey Bay southward through the coast ranges to Baja, Mexico (Hunt 1994). It prefers quiet waters of ponds, small lakes, streams, and marshes, and requires basking sites such as partially submerged logs, rocks, mats of floating vegetation, or open mud banks. The SWPT will often inhabit reaches of streams that contain deep pools, with depths greater than three feet (Stebbins 1972). They are typically found in the largest and deepest pools along streams containing suitable basking sites, including fallen trees and boulders. They also tend to congregate along portions of streams containing abundant underwater cover or areas containing escape routes beneath the water surface such as undercut banks, tangles of roots, and submerged logs (Hunt 1994). Overland movements up to 5 km have been recorded, and these are thought to be in response to adverse environmental circumstances (e.g., drought), or normal movements within home ranges (D. Holland 1994). Along the central coast, mating occurs during April to May, and eggs (3 to 11) are typically laid from March through August within nests constructed in sandy banks. Incubation of eggs may range to approximately three months, with young turtles reaching sexual maturity in about eight years. Southwestern pond turtles are considered omnivores, feeding on vegetation, insects, fishes, frogs, and carrion.

The SWPT is designated as a Federal Special Concern species, and is considered Protected and a Special Concern Species by the CDFG. D. Holland (1994) estimates that 80 to 85% of the turtle populations (including both SWPT and northwestern pond turtle, *C. m. marmorata*) in California have been eliminated primarily due to land conversion, collecting, disease, non-native predators, urbanization, and flood control practices. Pond turtles are known to occur throughout the San Luis Obispo Creek corridor and many of its tributaries (Fugro 1995), with specific occurrences known from upper Stenner Creek and SLO Creek near the East Fork confluence (Havlik *in litt*., Morro Group 2000a).

Monarch Butterfly (*Danaus plexippus*)

Monarch butterfly uses *Eucalyptus* woodland, as well as other habitat types, for winter roost sites and has been observed to roost in a variety of areas throughout the Los Osos, Morro Bay, and San Luis Obispo regions. Primary roost sites include Montana de Oro and Morro Bay state parks, and scattered areas throughout the communities of Los Osos and Morro Bay. The over-wintering habitats for this

species are of special concern and protected by the CDFG. The NDDB (2000a) maps wintering occurrences of monarch butterfly in the Prefumo Creek drainage, and within the SLO Creek corridor near the Madonna Road Bridge.

Yellow Warbler (*Dendroica petechia*)

Yellow warblers are migratory and are broadly distributed throughout North America, though their California distribution is largely restricted to the northern and coastal portions of the State, and the Sierra Nevada foothills. Within San Luis Obispo County, this species is a fairly common summer transient of deciduous riparian habitats. Breeding and nesting of yellow warbler typically occurs from mid-April to early August, with peak activity occurring in June. Eggs (typically 3 to 6) are incubated for approximately 11 days, and young fledge approximately 9 to 12 days thereafter. The nesting lifestage of yellow warbler is considered sensitive (California Special Concern) by CDFG. Brood parasitism by brown-headed cowbirds has reportedly reduced numbers of this species statewide, though predation and destruction/clearing of riparian habitat is also implicated in population declines of this species. Suitable habitat for this species exists throughout the SLO Creek watershed within riparian scrub habitats.

Willow Flycatcher (*Empidonax traillii*)

Willow flycatcher is a small, migratory passerine that ranges across North America, and is a rare spring transient and an uncommon summer/fall migrant to San Luis Obispo County. This species more commonly is found as a summer resident within mountainous wet meadow and montane riparian habitats of the Sierra Nevada and Cascade ranges after migrating from winter habitat in Central and South America. Dense willow thickets are required for nesting and roosting, with peak egg laying occurring in June. Young fledge within 13 to 14 days. Willow flycatcher is considered a California Species of Concern, primarily due to destruction of riparian scrub habitat and to cowbird brood parasitism. No nesting records of this species exist within San Luis Obispo County (T. Edell, Caltrans biologist, pers. comm.), though riparian areas of the SLO Creek watershed could provide suitable habitat.

Tidewater Goby (*Eucyclogobius newberryi*)

The tidewater goby is a small (to 50 mm), native species found along the Pacific coast of California from Humboldt County south to San Diego County (Moyle 1976). While most gobies are strictly marine fishes, the tidewater goby is one of two California goby species found in and near freshwater for a significant portion of its life. In coastal streams, gobies are usually found in slow moving reaches or within pools away from excessive current. Spawning generally occurs from April through June. Tidewater gobies are present within Reach 1 of SLO Creek, and are relatively abundant immediately downstream of the Marre Dam (Swenson 1995).

Yellow-breasted Chat (*Ictera virens*)
The yellow-breasted chat is a migratory species distributed throughout the United States, though it is noted as an uncommon summer resident of the coast and Sierra Nevada foothills of California. Preferred habitat for cover, foraging, and nesting consists of willow riparian thickets, with dense understory cover. In San Luis Obispo County, observations of yellow-breasted chat are limited to uncommon occurrences from May to mid-August, concurrent with their breeding period, which peaks in June. Eggs (3 to 6 typically) are incubated for 11 to 15 days, with chicks fledging 8 to 11 days thereafter. The nesting lifestage of yellow-breasted chat is considered sensitive by the CDFG, and this species is listed as a California Special Concern species. Habitat loss and cowbird brood parasitism (similar to yellow warbler, above) are implicated in population declines. No nesting records for this species exist in the watershed (T. Edell, Caltrans biologist, pers. comm.), though riparian scrub habitats of the SLO Creek watershed could provide migratory habitat (resting/feeding).

Southern Steelhead Trout (*Oncorhynchus mykiss irideus*)
Steelhead are known as the anadromous form of rainbow trout (McEwan and Jackson 1996). Steelhead historically ranged from Alaska southward to the California-Mexico border, though current data suggest that the Ventura River is presently the southernmost drainage supporting substantial steelhead runs. Periodically, steelhead are reported within the Santa Clara River and Malibu Creek. Southern steelhead are important in that they represent the southernmost portion of the native steelhead range in North America, having ecologically and physiologically adapted to seasonally intermittent, coastal California streams.

Optimal habitat for steelhead throughout its entire range on the Pacific Coast can generally be characterized by clear, cool water with abundant instream cover (i.e., submerged branches, rocks, logs), well-vegetated stream margins, relatively stable water flow, and a 1:1 pool-to-riffle ratio (Raleigh et al. 1984). However, steelhead are occasionally found in reaches of streams containing habitat that would be considered less than optimal. Steelhead within the central coast region begin moving up coastal drainages (including SLO Creek) following the first substantial rainfall of the fall season. Spawning typically occurs in the spring in riffle areas that consist of clean, coarse gravels (Moore 1980). Deposited eggs incubate for approximately 3 to 4 weeks, with hatched fry rearing within the gravel interstices for an additional 2 to 3 weeks. Emergent fry rear at the stream margins near overhanging vegetation. Juveniles (smolts), after rearing for 1 to 3 years within freshwater, and post-spawning adults migrate out to the ocean from March to July, depending on streamflows. Therefore, juvenile steelhead can be found within SLO Creek at all times of the year, while adults are likely to be found from approximately February to July.

All populations of steelhead occurring within the South-Central California Coast Evolutionary Significant Unit (ESU) Region—which is defined as that geographic region north of the Santa Maria River, northward to (and including) the Pajaro River

(and it's tributaries), Santa Cruz County—were listed as Federally Threatened by the National Marine Fisheries Service (NMFS) in August 1997. San Luis Obispo Creek (including its major tributaries) was recently listed by the NMFS as critical habitat for this species (Federal Register 2000). Southern steelhead trout are also considered a California Special Concern species. The NMFS lists habitat deterioration due to sedimentation and flooding related to land management practices, and potential genetic interaction with hatchery rainbow trout, as risk factors to steelhead within this ESU. Southern steelhead trout are distributed throughout the San Luis Creek watershed, including most of it's major tributaries. The extent of steelhead distribution within the San Luis Obispo Creek watershed is summarized in SLOLC (2002).

California Red-legged Frog (*Rana aurora draytonii*)

The California red-legged frog historically ranged from Marin County southward to northern Baja California. Presently, Monterey, San Luis Obispo, and Santa Barbara counties support the largest remaining CRLF populations within the State. CRLFs prefer aquatic habitats with little or no flow, the presence of surface water to at least early June, surface water depths to at least 2.3 feet, and the presence of fairly sturdy underwater supports such as cattails. The largest densities of this subspecies are typically associated with dense stands of overhanging willows and an intermixed fringe of sturdy emergent vegetation.

CRLF typically breed from January to July, with peak breeding occurring in February. Eggs are attached to subsurface vegetation, and hatched tadpoles require 11 to 20 weeks to metamorphose. It is estimated that only 1% of eggs actually reach adulthood. This species was formally listed by the USFWS as Federally threatened in 1996, and is considered a California Special Concern species, and Protected species, by the CDFG. Riparian habitat degradation, urbanization, predation by bullfrogs, and historic market harvesting has all reportedly contributed to population declines in this species.

Suitable habitat as described above does exist within the watershed. However, CRLF have often been observed in unsuitable habitat (concrete ponds, roadside ditches) and the presence of water indicates that CRLF may be encountered. Documented populations of CRLF are located in Prefumo Canyon, and in Gragg Canyon. No CRLF sightings have been reported on the mainstem of San Luis Obispo Creek.

California Spotted Owl (*Strix occidentalis occidentalis*)

The California spotted owl has been documented in riparian woodlands of upper See Canyon, within the San Miguelito Creek sub-watershed. Suitable habitat includes dense, multilayered forests. Summer roosts generally include dense forest canopies on north-facing slopes, while winter roosts generally include oak forestland. Usually nest in tree cavities or broken tops of trees. Noted as an uncommon resident of San Luis Obispo County (Edell et al. 1985), and unlikely to be very abundant within the study area.

Coast Range Newt (*Taricha torosa torosa*)

California newts (*T. torosa*) consist of two subspecies: Coast Range newt and Sierra newt. The former ranges discontinuously along the coast of California from Mendocino County to San Diego County. Optimum habitats reportedly consist of valley-foothill hardwood forest in association with rivers, creeks, ponds, and lakes. Coast Range newts have both terrestrial and aquatic life history phases. Adults are largely inactive, aestivating within subterranean refuges during most of the year. Following the first rains of fall, adults migrate to water, with mating occurring from September to May. Adhesive egg masses are deposited on submergent vegetation and rocks from May to June, with larvae hatching 5 to 7 weeks thereafter. Larvae transform to adults during the summer or fall of their first year. Sexual maturity is reached at approximately the end of the first year. Post-metamorphic juveniles and adults eat earthworms, snails, slugs, sowbugs, and insects. Adults within breeding ponds eat insects, crustaceans, and snails, and the eggs of other amphibians and trout, as well as eggs of their own species. The CDFG considers those populations of *T. torosa torosa* distributed from San Luis Obispo County southward as California Special Concern species. Riparian degradation related to urban development has likely contributed to population declines. This species is seasonally abundant within the upper reaches of several San Luis Obispo County creeks, including SLO Creek near Cuesta Grade, Morro Creek near Cerro Alto campground, and the uppermost reaches of Toro Creek (J. Tupen, Morro Group biologist, pers. obs.).

Two-Striped Garter Snake (*Thamnophis hammondii*)

The two-striped garter snake is a highly aquatic species, and is associated with semi-permanent to permanent freshwater habitats containing substantial emergent vegetation. It is also typically found in perennial pools containing frogs and fish, which are their primary prey (Zeiner et al. 1988). This species is considered a California Special Concern Species, and is protected by the CDFG. Suitable habitat for this species exists throughout the San Luis Obispo Creek watershed.

Reach by Reach Conditions

The following descriptions of individual creek reaches are compiled from the Phase I and II San Luis Obispo Creek studies and the literature and studies noted in Section 1 – Background and Section IV – References. An overview of the vegetative occurring in the study area is presented in Table B-5 – Reach-by-Reach Vegetation Summary. A summary of instream habitat characteristics is presented in Table B-6.

TABLE B-5
Reach-by-Reach Vegetation Summary*

Creek	Reach	Tree Species	Shrub Species	Grass Species	Exotic Species
San Luis Obispo Creek	1	Arroyo willow	Black sage	Perennial-intro.	Cape ivy
		Black cottonwood	Blackberry		Castor bean
		California bay	Coyote bush		Kikuyu
		California sycamore	Holly-leaf cherry		Mustard
		Coast live oak	Poison oak		Pampas grass
		Eucalyptus	Toyon		Vinca
		Hinds walnut			
		Mixed willow			
		Ornamental			
		Pepper Tree			
	2	Black cottonwood	None Recorded	None Recorded	Arundo
		Box elder			Cape ivy
		California sycamore			Castor bean
		Coast live oak			Cocklebur
		Eucalyptus			
		Hinds walnut			
		Mixed willow			
	3	Black cottonwood	None Recorded	None Recorded	Arundo
		Box elder			Cape ivy
		Hinds walnut			Castor bean
		Mixed willow			
	4	Box elder	Blackberry	None Recorded	Arundo
		California sycamore	California wild rose		Cape ivy
		Hinds walnut	Coyote bush		Castor bean
		Mixed willow			Hemlock
		Ornamental			Kikuyu
	5	Arroyo willow	None Recorded	None Recorded	Arundo
		Black cottonwood			Cape ivy
		Box elder			Castor bean
		California sycamore			Cocklebur
		Hinds walnut			Fennel
		Mixed willow			Hemlock
		Ornamental			Mustard
		Pepper tree			
	6	Box elder	Blackberry	Perennial-native	Arundo
		California bay	Coyote bush		Cape ivy
		California sycamore			Castor bean
		Eucalyptus			Cocklebur
		Hinds walnut			Fennel
		Mixed willow			Hemlock
		Monterey pine			Iceplant
		Ornamental			Kikuyu
		Pepper tree			Mustard
					Ox-tongue
					Scotch broom
					Smilo grass
					Star thistle
					Tree tobacco

Creek	Reach	Tree Species	Shrub Species	Grass Species	Exotic Species
San Luis Obispo Creek	7	Black cottonwood	Blackberry	None Recorded	Arundo
		Box elder			Cape ivy
		California sycamore			Castor bean
		Coast live oak			Cocklebur
		Eucalyptus			Fennel
		Hinds walnut			Hemlock
		Mixed willow			Kikuyu
		Ornamental			Mustard
					Sweet clover
	8	Arroyo willow	Coyote bush	Perennial - intro	Castor bean
		Eucalyptus			
		Hinds walnut			
		Mixed willow			
		Primary successional			
	9	Arroyo willow		Perennial - intro	Castor bean
		Black cottonwood			Groundcover
		California sycamore			Ornamentals
		Eucalyptus			
		Hinids walnut			
		Mixed willow			
		Monterey cypress			
		Monterey pine			
	10	Arroyo willow			Castor bean
		Black cottonwood			Ornamentals
		California sycamore			
		Eucalyptus			
		Mixed willow			
		Montery pine			
	11	Arroyo willow	Blackberry	None Recorded	Cape ivy
		Black cottonwood	California wild rose		English ivy
		Black locust	Coffeeberry		Fennel
		Black walnut	Coyote bush		Himalayan berry
		California sycamore	Elderberry		Honeysuckle
		Coast live oak	Ornamental		Ipomoea
		Eucalyptus	Poison oak		Kikuyu
		Hinds walnut	Snowberry		Vinca
		Mixed willow			
		Monterey pine			
		Ornamental			
		Pepper tree			
	12	Arroyo willow	Elderberry	None Recorded	English ivy
		Black walnut	Poison oak		Kikuyu
		California sycamore	Toyon		Pampas grass
		Coast live oak			Pyrocantha
		Eucalyptus			Scotch broom
		Mixed willow			Vinca
		Monterey pine			
		Ornamental			
		Pepper tree			
		Arroyo willow	Coyote bush	Perennial-intro	Arundo

Creek	Reach	Tree Species	Shrub Species	Grass Species	Exotic Species
San Luis Obispo Creek	13	Black cottonwood	Elderberry	Perennial-native	English ivy
		Black walnut	Poison oak		Honeysuckle
		California bay	Toyon		Kikuyu
		California sycamore			Pampas grass
		Coast live oak			Scotch broom
		Eucalyptus			Vinca
		Monterey pine			
		Ornamental			
		Pepper tree			
		Arroyo willow	California sagebrush	Perennial - intro	Groundcover
	14	Black cottonwood	coyote bush		
		California sycamore			
		Coast live oak			
		Eucalyptus			
East Fork of San Luis Obispo Creek	15	Eucalyptus	blackberry	Perennial-intro	castor bean
		Hinds walnut			hemlock
		Mixed willow			mustard
	16	Arroyo willow	blackberry	Perennial-intro	cocklebur
		Black walnut		Perennial-native	hemlock
		Eucalyptus			kikuyu
		Hinds walnut			mustard
		Mixed willow			ox-tongue
					teasal
Prefumo Creek	17	Arroyo willow	Coyote bush	Perennial - intro	
		Black locust			
		California sycamore			
		Coast live oak			
		Mixed willow			
	18	Eucalyptus	blackberry	Perennial-intro	Arundo
		Hinds walnut			English ivy
		Mixed willow			Kikuyu
		Ornamental			Pampas grass
					Phalaris
					Phoenix palm
					Vinca
Stenner Creek	19	Arroyo willow	None Recorded	None Recorded	Cape ivy
		Black walnut			Castor bean
		California bay			English ivy
		California sycamore			Himalaya berry
		Eucalyptus			Phoenix palm
		Ornamental			Vinca
	20	Arroyo willow	Blackberry	Perennial-intro	Arundo
		Black walnut			Cape ivy
		Box elder			Castor bean
		California sycamore			English ivy
		Coast live oak			Himalaya berry
		Eucalyptus			Kikuyu
		Monterey cypress			Phoenix palm
		Monterey pine			Vinca
		Ornamental			

Creek	Reach	Tree Species	Shrub Species	Grass Species	Exotic Species
Stenner Creek	21	Arroyo willow	Blackberry	None Recorded	Cape ivy
		Black cottonwood	Poison oak		Castor bean
		Black locust			English ivy
		Black walnut			Kikuyu
		Box elder			Pampas grass
		California bay			Phoenix palm
		California sycamore			Vinca
		Coast live oak			
		Eucalyptus			
		Hinds walnut			
		Mixed willow			
		Ornamental			
		Pepper tree			
	22	Arroyo willow	Blackberry	Perennial-intro	Arundo
		Black cottonwood	Coffeeberry		Cape ivy
		Black locust	Coyote bush		Castor bean
		Black walnut	Poison oak		Cocklebur
		California bay	Toyon		Fennel
		California sycamore			Kikuyu
		Coast live oak			Phoenix palm
		Eucalyptus			Scotch broom
		Mixed willow			Vinca
		Ornamental			
		Pepper tree			
Brizziolari Creek	23	Arroyo willow	Coffeeberry	Perennial-intro	Cape ivy
		Black cottonwood	Coyote bush		Castor bean
		California bay	Elderberry		Cocklebur
		California sycamore			Fennel
		Coast live oak			Grapevine
		Eucalyptus			Kikuyu
		Mixed willow			Pampas
		Ornamental			Phoenix palm
		Pepper tree			
See Canyon Creek	24	Arroyo willow	Coffeeberry	None recorded	unknown
		Black walnut	Coyote brush		
		Coast live oak	Elderberry		
		Mixed willow			
		Sycamore			

* plants listed are taken from both Phase I and Phase II observations and inventories

TABLE B-6
Instream Habitat Characteristics

Reach ID	Reach Location	Reach Length in km (ft)	Habitats (#) P	Habitats (#) R	Habitats (#) FW	Habitats (%) P	Habitats (%) R	Habitats (%) FW	Pools #/km	Pools Length (m)
SLO Creek 1	Mouth to Lower SLBD Bridge	2.98 (9770.6)	2	0	1	1.1	0	98.9	0.67	16.8
SLO Creek 2	Lower SLBD Bridge to Ontario Rd.	1.65 (5413)	28	0	31	51.8	0	48.2	16.7	18.1
SLO Creek 3	Ontario to Upper SLBD Bridge	1.61 (5298.5)	29	2	33	34.1	1.8	64.2	18.0	19.0
SLO Creek 4	Upper SLBD Bridge to wood bridge	1.10 (3618.5)	12	6	17	27.3	9.4	63.3	10.9	25.1
SLO Creek 5	Wood bridge to 2nd wood bridge	2.07 (6784.5)	27	8	43	18.4	7.9	73.7	13.0	14.1
SLO Creek 6	2nd wood bridge to SHSB	0.95 (3126)	10	2	20	13.4	2.8	83.8	10.5	12.8
SLO Creek 7	SHSB to LOVR Bridge	1.82 (5984.5)	27	6	34	18.7	6.0	75.3	14.8	12.6
SLO Creek 8	LOVR to Prado Rd	2.16 (7073)	33	1	61	15.4	0.7	83.9	15.3	10.1
SLO Creek 9	Prado Rd to Madonna Rd	1.63 (5355)	15	1	153	6.5	0.2	93.3	9.2	8.1
SLO Creek 10	Madonna to Stenner Cr	1.24 (4083)	8	2	28	4.7	2.9	92.4	6.5	7.3
SLO Creek 11	Stenner Cr to California St Bridge	2.47 (8108)	6	9	64	1.3	6.4	92.4	2.4	5.2
SLO Creek 12	Cal St Bridge to Andrews St Bridge	0.23 (770)	2	1	6	6.0	4.8	89.2	8.7	7.0
SLO Creek 13	Andrews St. to 101 overpass at Cuesta Park	1.22 (4006)	6	3	25	8.3	3.0	88.7	4.9	17.0
SLO Creek 14	Cuesta Park to Stagecoach Rd	4.70 (15427)	9	3	51	0.8	2.3	96.9	1.9	4.5
East Fork 15	East Fork to Santa Fe Rd	1.65 (5420.9)	3	10	18	1.4	15.1	83.5	1.8	7.5
East Fork 16	Confluence to Acacia Creek	2.72 (8936.3)	6	4	13	5.5	2.9	91.6	2.2	25.1
Prefumo Creek 17	Laguna Lake inlet to SLO City limits	1.86 (6105)	10	6	18	4.5	2.7	92.7	5.4	27.6
Prefumo Creek 18	SLO Creek confluence to Laguna Lake outlet	1.9 (6237)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Stenner Creek 19	Confluence to Chorro St.	0.28 (761.2)	1	3	4	2.0	37.3	60.7	3.5	4.7
Stenner Creek 20	Chorro St. to Santa Rosa St.	0.68 (2240.5)	6	11	15	6.3	30.7	63.0	8.8	7.2
Stenner Creek 21	Santa Rosa St. to Brizziolari confl.	0.76 (2507.2)	7	14	20	4.3	26.5	69.2	9.2	4.7
Stenner Creek 22	Brizziolari confl. to Stenner Ck Road	2.19 (7191.9)	21	20	28	7.0	20.7	72.3	9.6	7.3
Brizziolari Cr. 23	Confluence to back of bldgs	1.79 (5867.1)	8	4	14	3.3	5.5	91.2	4.5	7.4
San Miguelito Cr. 24	Not surveyed for instream character									
Old Garden Cr.	Confluence to Foothill	1.75 (5727.7)	8	7	13	2.8	12.7	84.5	4.6	6.3

Reach 1 – San Luis Obispo Creek

Reach 1 is 3 km (9,771 ft) in length, and is unique among all areas treated within the present study in that it is subject to tidal influence, and therefore, partly saline in water chemistry. A sheet pile dam (Marre Dam) constructed in the 1960's, approximately mid-way through this reach, separates the brackish portion of Reach 1 (below dam) from the freshwater portion above the dam to the bridge. The majority of Reach 1 below the dam flows through the Avila Beach Resort Golf Club. Historically, San Luis Obispo Creek upstream to the lower San Luis Bay Drive Bridge (reach boundary) was subject to tidal influence, and estuarine species such as starry flounder (*Platichthys stellatus*) and shiner perch (*Cymatogaster aggregata*) were periodically observed from the bridge platform (Kresja, pers. comm.). Construction of the dam, proposed as necessary to prevent salt intrusion into agricultural well points, functionally truncated the size of the San Luis Obispo Creek estuary habitat.

Presently, streamside vegetation within the portion of Reach 1 below Marre Dam is dominated by a dense, mixed willow stand immediately downflow of the dam. However, the majority of this portion of Reach 1 is fairly degraded, with no substantial riparian component throughout the golf course property. Vegetation within this lower portion of Reach 1 consists largely of herbaceous species, including non-native grasses, pickleweed, and saltgrass. Above Marre Dam, the riparian corridor is relatively intact. Dominant tree species include arroyo willow, coast live oak, black cottonwood, and California sycamore. The shrub layer is dominated by coyote brush, with toyon, poison oak, black sage (*Salvia mellifera*), and holly-leafed cherry (*Prunus ilicifolia*). Exotics are fairly abundant within Reach 1, with representative species including castor bean, pampas grass (*Cortaderia selloana*), cape ivy, *Vinca*, summer mustard, and kikuyu grass.

The entirety of Reach 1 can be considered a uniform, somewhat characterless flatwater, with only two pools inventoried during mapping efforts in 2001. Marre Dam appears to indicate the only discernable stream gradient change within this reach, with an elevational difference on either side of the dam of approximately 1m during low tide events. During such events, a fairly deep (~2m) pool exists immediately downflow and adjacent to Marre Dam. This pool is parallel to the sheetpile dam alignment, and presumably is formed and maintained by dam overtopping during high-flow events. Tidewater gobies (*Eucylogobius newberryi*), listed by the USFWS as federally endangered in 1994, were present within this pool during surveys conducted by Ramona Swenson in July 1995 (Swenson 1995). Several small (<2m long, 1m deep) lateral scour pools were present in the San Luis Obispo Creek mainstem within 100m downstream of the dam during a June 2001 site visit (J. Tupen, pers. obs.). No fish were observed within those pools at that time.

Reach 2 - San Luis Obispo Creek

Reach 2 is located from lower San Luis Bay Drive Bridge upstream to Ontario Road, a distance of 1.65 km (5,413 ft). The lowest 183 m (600 ft) of Reach 2 is subject to pooling from the downstream Marre Dam impoundment (SLOLC 1996). Major streamside development within this reach includes cabanas associated with Sycamore Mineral Springs, Avila Hot Springs, and Avila R/V Park and Resort. Agricultural

orchards (apples) are also present immediately upstream of the bridge. The riparian habitat of Reach 2 is characterized by a multi-layered and polytypic mix of native species. Large California sycamores and black cottonwoods are abundant. This hardwood dominated tree layer is replaced with mixed willows near the Ontario Road Bridge, where Cleveland (1996) noted that the creek channel was "choked" with willows. Cape ivy is abundant throughout the reach, and *Arundo* is common near the bridge.

The instream habitat of Reach 2 is afforded substantial shade by the dense riparian vegetation. Cleveland (1996) noted that 51.8% (of the total reach length) of Reach 2 consisted of pool features, with 48.2% characterized as flatwaters. No riffles were inventoried within this reach. Overall, Cleveland inventoried 28 pools within Reach 2, for a pool #/reach length ratio of approximately 16.7 pools/km (second highest ratio within watershed). The mean pool length within this reach was 18.1 m, with most of the pools identified as root wad enhanced- or bedrock formed-lateral scour pools (Cleveland, 1996). The confluence of San Miguelito Creek (See Canyon Creek) is located within the lower portion of Reach 2.

Reach 3 - San Luis Obispo Creek

Reach 3 is located from Ontario Road upstream to the upper San Luis Bay Drive Bridge, a distance of 1.61 km (5,299 ft). This reach is largely undeveloped and rural, with some active cattle grazing evident. Several large-parcel residences are present, as is an R/V Park near the Ontario Road Bridge. Excessive bank erosion and slumping was reported by Cleveland (1996), presumably due to cattle grazing practices. The riparian canopy of Reach 3 is dominated by mixed willows, with box elder, Hinds walnut (*Juglans hindsii*), and black cottonwood also present. Mature sycamores are absent from Reach 3, reportedly reflecting historic channelization activities (SLOLC 1996). Shrub and herbaceous components are scarce to nonexistent, perhaps reflecting grazing pressure over time. Exotics include thick cape ivy, with castor bean and *Arundo* also noted.

The instream habitat of Reach 3 is similar in composition to that of Reach 2, with 29 pools inventoried over the extent of the reach for a ratio of 18 pools/km (highest pool ratio in watershed). Overall, 34.1% of Reach 3 consisted of pool features and 64.2% was characterized as flatwater habitat. Riffles composed less than 2% of the total habitat of Reach 3. Mean pool length within this reach was 19.0 m, with most of the pools identified as log enhanced- or root wad enhanced-lateral scour pools (Cleveland 1996). Cleveland (1996) also noted the existence of a gently sloped (4.1:50 ft) fish ladder within Reach 3 near Highway 101.

Reach 4 - San Luis Obispo Creek

Reach 4 is located from the upper San Luis Bay Drive Bridge upstream to a wooden bridge located on the DeVincenzo property, a distance of approximately 1 km (3,619 ft). Land use within this reach is largely agricultural, with active apple orchards dominating the land areas west of San Luis Obispo Creek. The riparian canopy of Reach 4 consists of mixed willows, Hinds walnut, and California sycamore. Shrub species include California wild rose, California blackberry, and coyote brush. Herbaceous, understory vegetation is scarce. Riparian vegetation is generally more degraded in the lower

portions of the reach, relative to the upper reach areas (SLOLC 1996). Reach 4 is particularly infested with cape ivy, with castor bean, *Arundo*, poison hemlock, and kikuyu grass also present. The Land Conservancy has pursued ivy eradication efforts on the right bank of Reach 4.

Twelve pools, six riffles, and 17 flatwater habitats were mapped by Cleveland (1996) within Reach 4, resulting in a derived pool frequency of nearly 11 pools/km. As such, approximately 27% of Reach 4 consisted of pool features, with 63.3% characterized as flatwater habitat and 9.4% mapped as riffle habitat. This riffle percentage was the highest noted within the watershed, and likely reflects a relatively large proportion of the overall stream gradient change (slope) within San Luis Obispo Creek. Mean pool length within this reach was 25.1 m (greatest in watershed), with most of the pools identified as log enhanced lateral scour pools (Cleveland 1996). Mid-channel pools and root wad enhanced lateral scour pools were also noted within this reach, as was a single, boulder-formed lateral scour pool (actually formed by concrete rubble along the stream bank). The SLOLC (1996) noted that lower portions of Reach 4 were historically channelized/straightened.

Reach 5 - San Luis Obispo Creek

Reach 5 is 2.07 km (6,785 ft) long, and is located from the wooden bridge on the DeVincenzo property upstream to a wooden agricultural bridge on the Bunnell property. Land use within Reach 5 reach is largely agricultural farming, with active cattle grazing present also. The riparian canopy of Reach 5 consists of mixed willows, Hinds walnut, black cottonwood, and California sycamore, with single-trunk hardwoods more common in the lower portion of the reach. Shrub species and herbaceous species were not conspicuous components of the Reach 5 riparian community. This reach, like most reaches within the lower San Luis Obispo Creek watershed, harbors an assortment of introduced, noxious plant species, including cape ivy, castor bean, *Arundo*, poison hemlock, cocklebur, summer mustard, and fennel. The confluence of Davenport Creek is located within the upper portion of Reach 5.

The instream habitat of Reach 5 consists of approximately 18% pools, 8% riffles, and 74% flatwaters, with an overall pool frequency of 13/km. Pool lengths averaged approximately 14 m within this reach. The frequency of riffle habitat within Reach 5 (similar to Reach 4) indicates a relatively large proportion of the overall stream gradient change within the watershed. Pool habitats within Reach 5 consisted largely of root wad enhanced lateral scour pools, with log enhanced- and boulder formed-lateral scour pools also present. A single, clay-formed, mid-channel pool was identified in the central portion of Reach 5

Reach 6 - San Luis Obispo Creek

The 0.95 km (3,126 ft) Reach 6 of San Luis Obispo Creek is located from the wooden agricultural bridge on the Bunnell property upstream to the South Higuera Street Bridge. Land use within this reach is largely agricultural, with field crops and cattle grazing present. The creek corridor is constricted within Reach 6, largely due to construction of South Higuera Street and Highway 101, and also due to agricultural encroachment. The

riparian canopy of Reach 6 is dominated by mixed willows, with Hinds walnut and Monterey pine also present. Shrub species include California blackberry and coyote brush. Native, perennial grasses were present within the herbaceous understory vegetation. Reach 6 was observed to support the widest diversity (though not necessarily greatest abundance) of exotics and noxious, weedy species within the surveyed watershed areas. Dominants included castor bean and cape ivy, though the following weedy species were also noted: *Arundo*, tree tobacco, Scotch broom, ice plant (*Carpobrotus edulis)*, fennel, yellow star thistle (*Centaurea solstitialis*), poison hemlock, kikuyu grass, summer mustard, cocklebur, bristly ox-tongue, and smilo grass (*Piptatherum miliaceum*).

Nearly 84% of the instream habitat areas of Reach 6 was characterized as flatwaters, with pools and riffles composing 13% and 3% of the remaining habitats, respectively. The pool frequency ratio within this reach was 10.5/km, with an average size pool of approximately 13 m in length. Of the 10 pools identified within Reach 6, nine were root wad enhanced- or boulder formed lateral scour pools, and one was a log enhanced lateral scour pool (Cleveland 1996). No mid-channel pools were evident within this reach during 1995 survey efforts. The East Fork of San Luis Obispo Creek joins the mainstem near the upper portion of Reach 6. The SLOLC (1996) notes that a portion of Reach 6 adjacent to Higuera Street was historically moved to its present alignment to facilitate the construction of Highway 101.

Reach 7 - San Luis Obispo Creek

Reach 7 is 1.82 km (5,985 ft) long, and is located from the South Higuera Street Bridge upstream to the Los Osos Valley Road (LOVR) Bridge. Land use within Reach 7 reach is largely agricultural, with most farming activity near the lower portions of the reach. The riparian canopy of Reach 7 consists largely of mixed willows, with Hinds walnut, black cottonwood, California sycamore, and *Eucalyptus* also present. Shrub species and herbaceous species were not conspicuous components of the Reach 7 riparian community, though California blackberry is somewhat abundant. Similar to Reach 6, the lower portion of the Reach 7 channel is constricted by urban encroachment and agricultural practices, and riparian vegetation is consequently less dense than areas near the LOVR Bridge. Non-native vegetation within this reach included cape ivy, castor bean, *Arundo*, poison hemlock, yellow sweet clover (*Melilotus officinalis*), cocklebur, summer mustard, kikuyu grass, and fennel. The channel within the upper portions of Reach 7 is wide relative to lower portions, and is more heavily infested with *Arundo* and cape ivy than other Reach 7 areas.

The instream habitat of Reach 7 consists of 18.7% pools, 6% riffles, and 75.3% flatwaters, with an overall pool frequency of nearly 15/km. Pool lengths averaged approximately 13 m within this reach. Pool habitats within Reach 7 consisted largely of bedrock formed lateral scour pools, with log enhanced- and root wad enhanced lateral scour pools also present. Two boulder-formed lateral scour pools and a single, mid-channel pool were also mapped by Cleveland (1996) within this reach. The mainstem channel was braided in two locations during survey work in 1995.

Reach 8 - San Luis Obispo Creek

Reach 8 is located from the Los Osos Valley Road Bridge upstream to the Prado Road Bridge, a distance of 2.16 km (7,073 ft). Land use within this reach includes commercial and residential development, and the San Luis Obispo Water Treatment Facility. Some agriculture usage is present near the upper portions of Reach 8 near Prado Road. The riparian corridor ranges in width from 5-15 m (Questa 1997), with arroyo willow and Hinds walnut dominating the sparse canopy vegetation. Understory species consist largely of exotics, such as castor bean and *Arundo*, with coyote brush also mapped as an important streamside component. Windrow vegetation atop the creek bank includes *Eucalyptus* and cypress. The SLOLC (1996) notes that periodic removal of vegetation for flood control purposes has exacerbated bank erosion problems within this reach.

Approximately 84% of Reach 8 was characterized as flatwater habitat by Cleveland (1996), with pools and riffles composing 15% and 1% of the remaining habitats, respectively. The pool frequency ratio within Reach 8 was 15.3/km, with the average size pool being approximately 10 m in length. Of the pools identified within Reach 8, most were classified as root wad enhanced- and bedrock formed lateral scour pools. Several log enhanced- and boulder-formed lateral scour pools were also inventoried within this reach, as was a single corner pool feature near the central portion of the reach. Prefumo Creek joins the mainstem near the lower portion of Reach 8. Gabions and rock rip rap revetments are present along the streambank at several location to stabilize actively eroding slopes. Reach 8 was identified by Questa (1997) as the reach most in need of bank erosion control measures, relative to other reaches in the watershed. A large portion of Reach 8 (between LOVR and the WWTP) was excavated to a 40 m wide floodplain in the 1970's for flood control (Questa 1997).

Reach 9 - San Luis Obispo Creek

Reach 9 is located from the Prado Road bridge upstream to the Madonna Road Bridge, a distance of 1.63 km (5,355 ft). Land use within this reach is largely urban, with the mainstem channel constricted between commercial development to the east and Highway 101 to the west. Several mobile home parks are located at or near the top of the bank of San Luis Obispo Creek. Riparian zone width and vegetation composition within this reach is similar to that of Reach 8, but significantly less dense. Riparian vegetation along this reach has been removed or degraded by encroaching development (SLOLC 1996). Several serpentine outcrops were noted by Cleveland (1996), and Questa (1997) identified several plant species of concern potentially occurring within this reach, including San Luis Obispo dudleya (*Dudleya murina)* and San Luis mariposa lily (*Calochortus simulans*). Several areas of severe streambank erosion are present within this reach, particularly near the former RRM Design building and the present Elks Lodge. Channel constrictions caused by *Arundo* infestations were noted immediately downstream of the Madonna Road Bridge (SLOLC 1996).

Cleveland (1996) characterized just over 93% of Reach 9 as flatwater habitat (second highest in watershed), probably reflecting the poor condition of creek habitat and general bank instability issues within the reach. Pools and riffles comprised 6.5% and 0.2% of

the surveyed habitats, respectively. The pool frequency ratio within Reach 9 was 9.2/km, with the average size pool being 8.1 m in length. Of the pools identified within Reach 9, most were classified as root wad enhanced, bedrock formed, or boulder formed lateral scour pools. Concrete apron, slabs, and rubble, and rock rip rap revetments are present along the streambank at several locations to stabilize actively eroding slopes. A low flow barrier to fish passage was noted by Cleveland (1996) as occurring just upstream of Padre Liquor (near intersection of Prado Road and South Higuera Street).

Reach 10 - San Luis Obispo Creek

Reach 10 is located from the Madonna Road bridge upstream to the confluence of Stenner Creek (behind Four Seasons Outfitters on Higuera Street), a distance of 1.24 km (4,083 ft). Land use within this reach is largely urban, with both commercial and residential development encroaching on the creek corridor. The riparian corridor ranges in width from 15-35 m (Questa 1997), with mixed willows and *Eucalyptus* dominating the canopy vegetation. Understory species consist largely of exotics, such as *Arundo*, castor bean, and cape ivy.

Approximately 92% of Reach 10 is classified as flatwater habitat, with pools and riffles composing nearly 5% and 3% of the remaining instream habitat areas, respectively. The pool frequency ratio within Reach 10 was 6.5/km, which represents one of the lowest frequencies noted within the watershed. Of the eight pools, averaging 7.3 m in length, identified within Reach 10, three were classified as root wad enhanced lateral scour pools, and five were classified as bedrock formed lateral scour pools. Concrete rip-rap and sack revetments, and gabions are abundant along the streambank at several locations, apparently reflecting attempts to stabilize actively eroding slopes adjacent to residential and commercial developments.

Reach 11 - San Luis Obispo Creek

Reach 11 is 2.47 km (8,108 ft) long, and is located from the Stenner Creek confluence upstream to the California Street Bridge. Land use within Reach 11 is almost entirely developed urban, as this reach passes directly through downtown San Luis Obispo. At several sections within the reach, San Luis Obispo Creek is passed beneath the City via tunnels, closed bridges, and culverts. Riparian vegetation within these areas is not surprisingly absent. Within those areas subject to sunlight, California sycamore, Eucalyptus, arroyo willow, and mixed willow canopies dominate riparian vegetation. Ornamental species are abundant. Shrub understory species, where present, include coyote brush, poison oak, blue elderberry (*Sambucus mexicana*), and California wild rose. Exotics are abundant within Reach 11, with species including cape ivy, English ivy, *Vinca*, kikuyu grass, fennel, *Arundo*, and Himalayan blackberry. Several revegetation projects are evident along this reach.

The instream habitat of Reach 11 consists of approximately 1% pool, 6% riffles, and 92% flatwaters, with an overall pool frequency of 2.4/km (second lowest in watershed). Pool lengths averaged approximately 5.2 m within this reach. Of the six pools identified within this reach by Cleveland (1996), three were bedrock formed lateral scour pools and

three were boulder formed lateral scour pools. Much, if not most, of the bank slopes within this reach are armored in some fashion (SLOLC 1996).

Reach 12 - San Luis Obispo Creek

The 0.23 km (770 ft) Reach 12 of San Luis Obispo Creek consists of a bedrock located between the California Street bridge and the (upstream) Andrews Street foot bridge. Land use within this reach is also urban, with residential development often occurring at the hinge (top) of the streambank. California sycamore, ornamentals, coast live oak, and arroyo willow dominate the riparian canopy vegetation, while toyon, poison oak, and blue elderberry compose the shrub understory. Herbaceous species were not a conspicuous component of the Reach 12 riparian corridor. English ivy and *Vinca* are the most abundant exotics within this reach, though Scotch broom, pampas grass, kikuyu grass, and *Pyracantha* were also noted.

The instream habitat of Reach 12 consisted of 6% pools, undoubtedly reflecting the abundance of bedrock substrate. Riffle habitat and flatwaters comprised approximately 5% and 89% of the instream habitat, respectively. The pool frequency ratio within this reach was 8.7/km, with the average size pool being approximately 7 m in length. Two pools identified within this reach were both classified as mid-channel pools, also reflecting the hard rock composition of this reach.

Reach 13 - San Luis Obispo Creek

Reach 13 is 1.22 km (4,006 ft) long, and is located from the Andrews Street Bridge upstream to the Highway 101 culvert above Cuesta Park. Land use within this reach is a mix of urban and agricultural development, with the latter use largely related to grazing on Cal Poly lands in the upper watershed. A canopy of California sycamore (particularly near Cuesta Park), coast live oak, arroyo willow, *Eucalyptus*, and various ornamentals dominate the riparian vegetation within Reach 13. Blue elderberry, coyote brush, toyon, and poison oak form the shrub component, and while both native and non-native perennial grass species dominate the herbaceous layer. Scotch broom, English ivy, and *Vinca* are the dominant exotics in this reach.

The instream habitat of Reach 13 consists of 8.3% pool, 3% riffles, and 88.7% flatwaters, with an overall pool frequency of nearly 5/km. Pool lengths averaged approximately 17 m within this reach. Of the six pools identified within this reach by Cleveland (1996), three were mid-channel pools, two were dammed pools, and one was classified as a bedrock formed lateral scour pool. Gabion baskets are present at several locations to stabilize eroding banks, and water is being pumped (extracted) by various landowners to irrigate landscapes (SLOLC 1996).

Reach 14 - San Luis Obispo Creek

Reach 14, the final reach inventoried within the San Luis Obispo Creek drainage, is 4.70 km (15,427 ft) long, and is located from the Highway 101 culvert above Cuesta Park upstream to the Stagecoach Road culvert beneath Highway 101. Land use within this reach is largely agricultural, with field crops and cattle grazing both evident. The riparian corridor within Reach 14 is dominated by a canopy of California sycamore in the lower

and upper portions of the reach, and by coast live oak within the central portions of the reach near Reservoir Canyon. The relatively dense canopy vegetation excludes the development of a dense shrub understory. Introduced perennial grasses form the dominant herbaceous component of the Reach 14 riparian community.

The instream habitat of Reach 14 consists of approximately 1% pool, 2% riffles, and 97% flatwaters, with an overall pool frequency of nearly 2/km. Pool lengths averaged approximately 4.5 m within this reach. Root wad enhanced lateral scour pools were most abundant within the reach (n = 5), relative to other pool types. The four remaining pools identified by Cleveland (1996) within Reach 14 were a log-enhanced lateral scour pool; bedrock formed lateral scour pool, a plunge pool, and a dammed pool.

Reach 15 – East Fork of San Luis Obispo Creek

The East Fork of SLO Creek is the largest sub-watershed within the SLO Creek watershed. The confluence of the East Fork with the mainstem of San Luis Obispo Creek is located near Higuera Street at the southernmost limits of the City of San Luis Obispo. Acacia Creek is a tributary to the East Fork, with its confluence point located approximately 0.4-km (0.25-mile) south of Buckley Road. Reach 15 is that approximately 1.65km (5,421 feet) portion of Acacia Creek between this confluence point and Santa Fe Road. Land use within Reach 15 is largely agricultural and historic industrial use associated with the Unocal Tank Farm. The riparian corridor of Acacia Creek throughout this reach is consequently narrowed, with dominant species including various willows and Hinds walnut. Blackberry and non-native grasses form the riparian understory. Exotics found within Reach 15 include perennial mustard, poison hemlock, and castor bean.

The instream habitat of Reach 15 consists of approximately 1% pool, 15% riffles, and 84% flatwaters, with an overall pool frequency of nearly 2/km. Pool lengths averaged approximately 7.5 m within this reach. This reach was not included in the Cleveland (1996) survey, and specific habitat classifications are not available.

Reach 16 - East Fork of San Luis Obispo Creek

Reach 16 is that 2.72km (8,936 ft) portion of the East Fork drainage from the confluence of San Luis Obispo Creek upstream to the Acacia Creek confluence point. Similar to Reach 15, the riparian corridor of this portion of the East Fork has been degraded through time by past and present agricultural practices. Canopy-forming riparian vegetation within the lower East Fork is scant to non-existent, reflecting agricultural practices and historic stream channelization activities (Morro Group 2000b). Rather, this section is characterized as a seasonal freshwater marsh. Dominant mid-channel vegetation includes tule (*Scirpus acutus*) and cattail, with streamside vegetation composed of a diverse mixture of noxious, weedy species. These exotics include fennel, bristly ox-tongue, common sow thistle (*Sonchus oleraceaus*), cocklebur, and poison hemlock. Surface flows within the lower East Fork are seasonally intermittent.

The instream habitat of Reach 16 is severely degraded, also reflecting past land use practices. The channel is incised, and the retreating banks provide a continuing source of

sedimentation and turbidity. Concrete debris has been dumped at the confluence of the East Fork with San Luis Obispo Creek in an attempt to halt the active headcutting (erosion) within the East Fork (Morro Group 2000b). Instream features consist of approximately 5.5% pools, 3% riffles, and 92% flatwaters, with an overall pool frequency of 2.2/km. Pool lengths averaged 25 m within this reach.

Reach 17 - Prefumo Creek

Prefumo Creek, a tributary to SLO Creek draining the Irish Hills west of San Luis Obispo, was inventoried from its confluence point with San Luis Obispo Creek near the intersection of Los Osos Valley Road and U.S. Highway 101, upstream to the western City limits of San Luis Obispo along Prefumo Canyon Road. Reach 17 is that portion of Prefumo Creek originating at the Laguna Lake inflow, upstream 1.86km (6,105 ft) to the western City limits boundary. Chaparral dominates the headwater region vegetation, with riparian species including arroyo willow, California sycamore, black locust, coast live oak, and coyote brush. Land use in this area is mainly residential suburban, with some agricultural use present also.

Cattle grazing in the upper watershed and in the lowlands near Foothill Blvd and Los Osos Valley Road has contributed to soil erosion and consequent sedimentation within Prefumo Creek. Laguna Lake, located at the approximate midpoint of the Prefumo Creek drainage corridor, acts as a settling pond for sediment originating in these upstream regions, reducing sedimentation to the mainstem of SLO Creek. Instream features within Reach 17 consist of 4.5% pools, 2.7% riffles, and 92.7% flatwaters, with an overall pool frequency of 5.4/km. Pool lengths averaged 27.6m within this reach. All mapped pool features within Reach 17 were boulder-formed lateral scour pools, and were formed around boulders, logs, or rootwads. Recent stream restoration projects within this reach conducted by the Land Conservancy of San Luis Obispo County should restore headwater region access to southern steelhead trout.

Reach 18 - Prefumo Creek

Reach 18 is that 1.9km (6,237 ft) portion of the Prefumo Creek drainage located between the Laguna Lake outflow near Madonna Road, downstream to the San Luis Obispo Creek confluence. Within this reach, the riparian corridor of Prefumo Creek is constrained and narrowed by existing agricultural operations, and both residential and commercial development. Eucalyptus forms the dominant canopy species in the upper portions of Reach 18 south of Madonna Road, with mixed willows present near the lower areas of the reach. Exotic vegetation is abundant within Reach 18, with dominants including *Arundo*, kikuyu grass, *Vinca*, English ivy, and pampas grass. Escaped ornamental species are abundant near the residential development south of Madonna Road and east of Los Osos Valley Road.

Instream habitat features within the 1.49km section of Prefumo Creek located between Calle Joaquin and the lake outflow were surveyed by Morro Group. Five pool features (one plunge, three mid-channel, and one lateral scour) ranging in length from 13m to 22m (average 17.4m) were located within this area, for a pool frequency of 3.4/km. The lowest portion of this reach between Highway 101 and the San Luis Obispo Creek

confluence was surveyed by Cleveland in 1997 as part of the Phase I studies. Two pools were reported by Questa (1997) within this lowest section, but it is difficult to determine from the record if these pools were located on the San Luis Obispo Creek mainstem or the lowest section of Prefumo Creek.

Reach 19 - Stenner Creek

Reach 19 of Stenner Creek is 0.28 km (761 ft) long, and is located from the San Luis Obispo Creek confluence point near south Marsh Street, upstream to the Chorro Street Bridge. Land use within this reach is entirely urban residential, with Stenner Creek abutting numerous residences. Urban encroachment has resulted in the artificial channelization of portions of this reach, with the consequent reduction of riparian vegetation. Streamside vegetation within this reach, where it does occur, consists of a diverse mixture of canopy-forming species, including *Eucalyptus*, black walnut, California sycamore, and arroyo willow. Shrub and herbaceous understory species are sparse. Escaped ornamental vegetation (*Vinca* and English ivy) dominates the exotic flora of this reach, with castor bean, cape ivy, Phoenix palm, and Himalayan blackberry also present

The instream habitat of Reach 19 consists of 2% pool, 37.3% riffles, and 60.7% flatwaters, with an overall pool frequency of 3.5/km. Pool lengths averaged approximately 5 m within this reach. The relatively high frequency of riffle habitat within this reach, relative to the SLO Creek mainstem, likely reflects differences in stream gradients between drainages. The SLOLC (1996) noted that flows within the lower portions of Stenner Creek are flashy, and that urban encroachment has contributed to significant pollutant loading in the lower Stenner Creek watershed.

Reach 20 - Stenner Creek

Reach 20 is 0.68 km (2,241 ft) long, and is located from the Chorro Street Bridge upstream to the Santa Rosa Street Bridge. Similar to Reach 19, this reach is intensively developed with residences, and the Stenner Creek corridor is consequently narrowed and sometimes channelized. Streamside canopy-forming vegetation within this reach consists of arroyo willow, various ornamentals, black cottonwood, *Eucalyptus*, California sycamore, and black walnut. California blackberry forms the dominant herbaceous understory throughout Reach 20. Exotics are abundant and similar in composition to those of Reach 19, though kikuyu grass seems to be the dominant exotic species. Instream habitat features of Reach 20 included 6.3% pools, 30.7% riffles, and 63% flatwaters, with an overall pool frequency of nearly 9/km. Pool lengths averaged approximately 7 m within this reach.

Reach 21 - Stenner Creek

Reach 21 is a 0.76 km (2507 ft) long section located from the Santa Rosa Street Bridge upstream to the Brizziolari Creek confluence point. Land use within this reach is a combination of commercial development, agricultural orchards, and row crops, with most of this reach passing through the lower Cal Poly property. Riparian vegetation includes arroyo willow, California sycamore, black walnut, coast live oak, *Eucalyptus*, and various ornamentals. Poison oak and California blackberry form the dominant understory flora.

Exotic vegetation is abundant and similar to Reach 20, with English ivy dominating. The instream habitat of Reach 21 consists of 4.3% pools, 26.5% riffles, and 69.2% flatwaters, with an overall pool frequency of 9.2/km. Pool lengths averaged approximately 5 m within this reach.

Reach 22 - Stenner Creek

Reach 22 is a 2.19 km (7,192 ft) long section located from the Brizziolari Creek confluence point upstream to Stenner Creek Road. Land use within this reach is almost entirely agricultural, with cattle ranching and row crop agriculture both present (SLOLC 1996). The entirety of this reach is within Cal Poly land holdings. Canopy-forming riparian species include coast live oak, California sycamore, arroyo willow, and *Eucalyptus*. Poison oak, California blackberry, coffeeberry, coyote brush, and toyon form the shrub understory, while perennial introduced grass species dominate the herbaceous cover. Exotics are abundant and similar in composition to other reaches within the watershed, with the addition of fennel, cocklebur, and Scotch broom. Instream features consist of 7% pools, 20.7% riffles, and 72.3% flatwaters, with an overall pool frequency of 9.6/km. Pool lengths averaged approximately 7 m within this reach.

Reach 23 - Brizziolari Creek

Brizziolari Creek, another tributary to Stenner Creek, was inventoried from its confluence point for an upstream distance of 1.79 km (5,867 ft). Land use within this sub-watershed is largely used for agriculture and cattle grazing associated with Cal Poly. While the riparian vegetation is generally in good condition, cattle entering the stream channel have eroded significant areas of streambank, contributing to excessive siltation. Instream features consist of approximately 3% pools, 6% riffles, and 91% flatwaters, with an overall pool frequency of 4.5/km. Pool lengths averaged approximately 7 m within this reach.

Reach 24 - San Miguelito (See Canyon) Creek

Reach 24 is the approximately 4km (13,200 ft) lowest portion of San Miguelito Creek. This drainage and it's associated sub-watershed are more rural and less developed than other tributaries to San Luis Obispo Creek. Land use is largely agricultural within the lowlands nearest San Luis Bay Drive, with residential development scattered throughout the lower and middle portions of the watershed. Streambank erosion exists along the lower portions of Reach 24 where See Canyon Road has encroached upon the drainage alignment. Dominant vegetation includes walnut, mixed oak, and sycamore canopies along the creek corridor, with mixed chaparral dominating the upper watershed land areas (SLOLC 1996). Instream habitats were not quantified by Cleveland (1996). However, the rural nature of this sub-watershed and the relatively undisturbed condition of its riparian corridor (SLOLC 1988) led SLOLC (1996, pg. 56) to note that "[San Miguelito Creek is] one of the best sub-watersheds for fish." San Miguelito Creek is reportedly one of the few tributaries to San Luis Obispo Creek providing both spawning and rearing habitat for southern steelhead trout (SLOLC 1988), with upstream migration impeded only by a dam located in the highest reaches of the watershed (SLOLC 2002).

Old Garden Creek

Old Garden Creek, a tributary to Stenner Creek, was inventoried from its confluence point to Foothill Blvd. for an upstream distance of 1.75 km (5,728 ft). Land use is largely urban residential, with Garden Creek forming a significant part of the landscape feature of many San Luis Obispo City residents. Riparian vegetation is sparse to non-existent due to urban encroachment. Grass lawns and ornamental vegetation are common along the streambank hinge. Similar to Stenner Creek, urban pollutant loading is a problem within this drainage. Instream features consist of approximately 3% pools, 13% riffles, and 85% flatwaters, with an overall pool frequency of 4.6/km. Pool lengths averaged approximately 6 m within this reach.

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APPENDIX C

Hydraulic and Hydrologic Report

HYDROLOGY AND HYDRAULIC STUDIES

This section summarizes the hydrologic and hydraulic analysis techniques used to determine design flow rates and water surface elevations. It provides information on the approach, methodology, and calibration of the models used to analyze and develop the flood management alternatives.

C-1.0 Watershed Hydrology

The purpose of hydrologic modeling on this project was to define design flow rates in San Luis Obispo Creek and its major tributaries for storms of various recurrence interval, ranging from the 2-year to the 100-year storm. This information will form the basis for the design and evaluation of flood management alternatives within the basin.

C-1.1 Hydrologic Modeling Approach

Questa's modeling approach has been to create a theoretical watershed runoff model using the U.S. Army Corps of Engineers' Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) computer modeling package. HMS is similar in computational ability to the old HEC-1 computer model but has a graphical user interface and allows for more detailed rainfall infiltration modeling and for greater GIS compatibility.

The model is composed of three components; watershed sub-basins, stream flow routing reaches, and modeled precipitation events. The watershed sub-basin component mimics the physical characteristics of the watershed including the relationship between precipitation and runoff. The flow routing component describes how flow moves from the upper reaches of the watershed to the mouth and determines the relative timing of this runoff. The precipitation component describes precisely how much rainfall occurs on each watershed sub-basin at each model time step.

The San Luis Obispo Creek Watershed above the mouth is approximately 217 square kilometers (84 square miles) in area. The topographic variability is quite impressive. Elevations vary from sea level to over 800 meters (2600 feet) along the crest of the Cuesta Ridge, in the Santa Lucia Mountains. No point in the watershed is more than 22 km (14 mi) from the coast. Storms coming off the Pacific Ocean are pushed over the mountains, tending to create widely varying rainfall patterns within the watershed. Precipitation in the lower Southeastern portions of the watershed can be less than half of that in the higher Northern portions. Flow in San Luis Obispo Creek can respond very quickly to short high intensity rainfall bursts. Floods in San Luis Obispo Creek tend to be of high magnitude and relatively short duration.

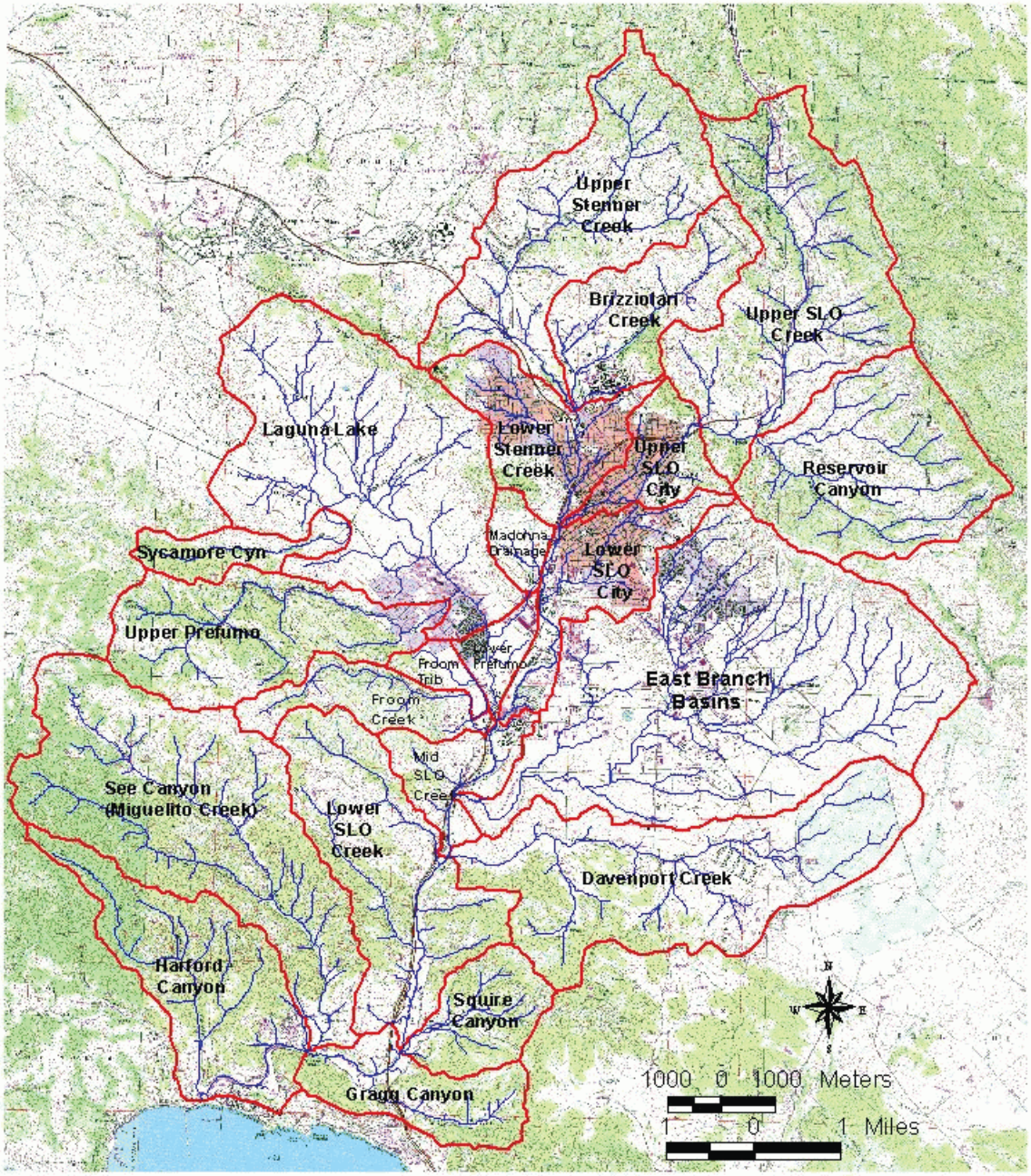

Figure C-1. Watershed Sub-Basin Boundaries

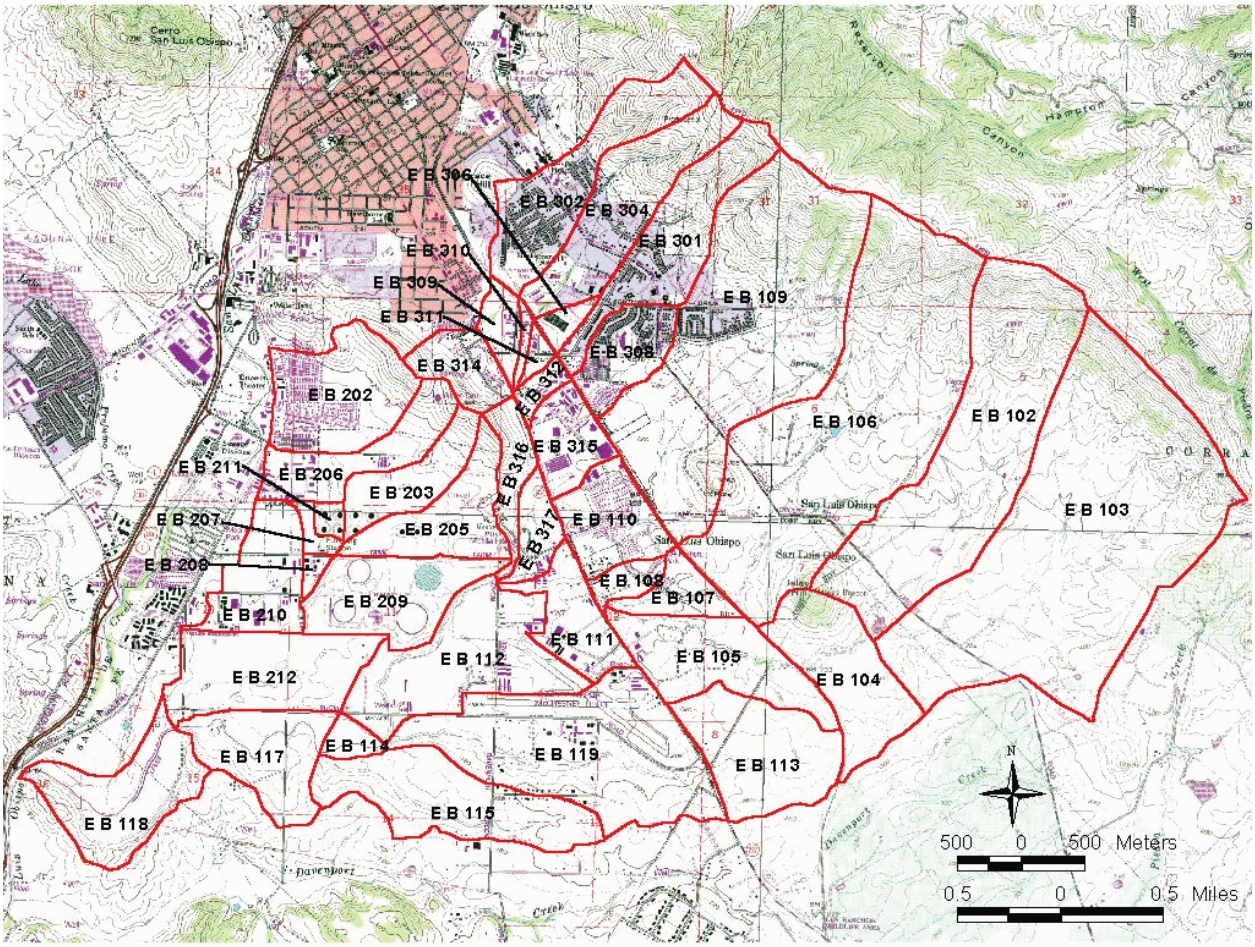

Figure C-2. Sub-basin delineation along the East Branch of San Luis Obispo Creek follows the *City of San Luis Obispo Storm Drain Master Plan* (Boyle Engineering Corporation, 1999).

C-1.2 Watershed Model

The watershed model was formed by splitting the watershed into 61 individual sub-basins (**Figure C-1**). To maintain consistency with the recently published *San Luis Obispo Storm Drainage Master Plan* (Boyle Engineering Corporation, 1999), basin boundaries within the watershed of the East Fork of San Luis Obispo Creek were taken from that report. The SCS loss-rate and the SCS unit hydrograph methods were used to determine runoff hydrographs from each of the sub-basins, based on a set of 24-hour design storms.

Loss-rate

In the SCS loss-rate method, infiltration properities of a basin are described by a runoff curve number. Curve numbers (CN) range from 1 to 100, with lower values denoting less runoff for a given precipitation total than higher values. The SCS curve number was typically calculated as a function of land use and soil hydrologic characteristics, according to Natural Resources Conservation Service (NRCS) recommendations outlined in Technical Report 55 (TR55) (Soil Conservation Service, 1975).

For this study, the goal was to develop runoff curve numbers representing four separate watershed conditions: pre-European settlement, historic circa 1960 conditions, existing conditions, and future conditions assuming general plan build-out. An individual runoff curve number map was created for each of the four watershed conditions. While it is possible to model changes in land use by changing an "impervious surface" variable in the SCS method, rather than by changing the curve number itself, this technique was not used as part of this study. Changes in curve number were the only way that change in infiltration characteristics over time were modeled.

The soil map shown in **Figure C-3** is based on published NRCS data, and is applicable for all four watershed conditions. Land use was determined using a combination of USGS quadrangle maps, recent aerial photography, city and county general plan land use maps, and several GIS vegetation coverages for the watershed. A future conditions land-use map (**Figure C-4**) was created by merging the city and county general plan land use maps and correlating the land use categories in those maps with land use categories defined by the NRCS (Soil Conservation Service, 1975). In the few locations where city and county data overlapped, the city land use category superceded the county category unless the city category was "open space," where the county map was assumed to be more representative. In areas zoned "open space," "agriculture," and "rural land," vegetation maps were overlain on top of the zoning map to better characterize those areas. Since only existing conditions vegetation maps were available, this technique assumes that vegetation characteristics in the rural parts of the watershed have been and will remain fairly constant over time.

Existing conditions land use was determined by comparing the general plan land use categories with recent aerial photography. Where the general plan land use did not appear to represent existing conditions as interpreted from a current aerial photograph, the land use category was changed to be more appropriate. This was most common directly south of San Luis Obispo.

Some areas zoned suburban or rural residential appeared on the aerial photographs to have not yet achieved total buildout. These areas were given the mean curve number between the most extensive existing vegetation type in the area and the curve number representing future general plan conditions.

There were two special cases where the existing condition land use was significantly less developed than the general plan buildout, and where simple averaging of undeveloped and post-buildout curve numbers would not be representative. These areas were See Canyon's area of "rural residential" zoning and the area of "suburban" zoning in Squire canyon. For See Canyon, we assumed that good condition brush characterized 75% of the basin and rural residential 25%. We weighted the curve numbers for these two categories accordingly. For Squire Canyon, we assumed that the existing condition was similar to the much less dense rural residential category, with 2-acre lots, and used that SCS category. Where areas were partly zoned suburban and partly grassland, we assumed that a rural residential 2-ac lot zoning was representative of existing conditions.

A similar method was used to define circa 1963 land use. This time, instead of adjusting general plan build-out curve numbers based on recent aerial photography, the general plan conditions were modified using a 1963 USGS quadrangle map. Where conditions on the historic USGS quadrangle differed from the general plan, a best estimate of the 1960's land use was made.

For pre-European settlement conditions, a curve number of 67.2 (calibrated), representing the average for undeveloped sub-basins in the existing conditions model, was applied to all sub-basins that in the 1960 model contained significant development. Essentially, this represents removing the city of San Luis Obispo and replacing it with land use that currently exists outside of the city limits. Otherwise, the pre-European settlement model is identical to the circa 1960 model.

Sub-basin curve numbers ranged from 61 to 79 (calibrated) were typically in the upper portions of the watershed (**Table C-1**).

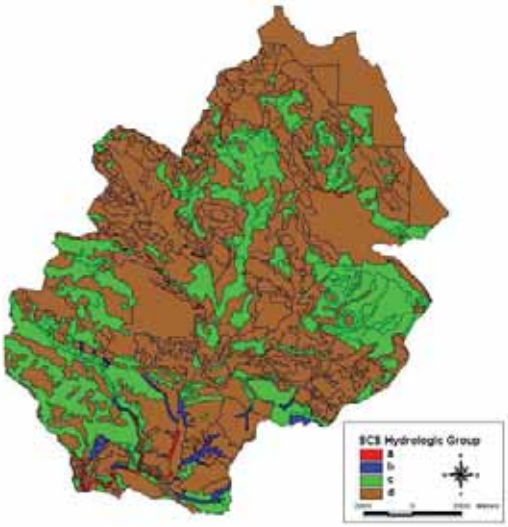

Figure C-3. Soil Hydrologic Groups.

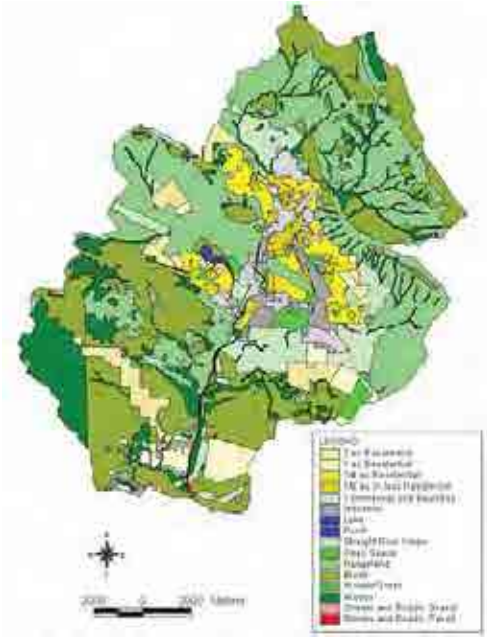

Figure C-4. NRCS Land Use Categories.

Table C-1. Loss Rate Parameters

Basin	Basin Area (km2)	Uncalibrated Existing Conditions SCS Curve Number	Calibrated Existing Conditions SCS Curve Number	Calibrated Future Conditions SCS Curve Number	Calibrated Historic 1965 Conditions SCS Curve Number	Calibrated Pre-European Settlement SCS Curve Number
Brizziolari Creek	7.28	83.7	71.2	71.2	70.7	67.2
Davenport Creek	17.97	77.1	65.6	65.6	65.9	65.9
Gragg Canyon	5.11	73.0	62.1	62.0	61.4	61.4
Froom Creek	7.57	76.1	64.7	64.8	67.8	67.2
Froom Tributary	1.12	82.2	69.9	74.3	67.8	67.2
Harford Canyon	11.09	70.3	59.7	60.1	59.5	59.5
Laguna Lake	21.69	83.4	70.9	70.9	70.7	67.2
Lower Prefumo	1.64	88.4	75.1	75.7	67.8	67.2
Lower SLO City	6.01	88.9	75.6	75.6	74.5	67.2
Lower SLO Creek	13.54	76.9	65.3	65.1	64.7	64.7
Lower Stenner	6.44	85.6	72.7	73.1	72.1	67.2
Madonna Drainage	1.56	82.7	70.3	70.3	67.8	67.2
Mid SLO Creek	3.57	81.5	69.3	69.3	67.8	67.2
Miguelito Creek	21.01	71.6	60.8	62.0	60.8	60.8
Reservoir Canyo	12.51	78.3	66.5	66.5	66.5	66.5
Squire Canyon	4.18	76.4	65.0	66.1	61.4	61.4
Sycamore Canyon	2.72	76.1	64.7	64.6	64.7	64.7
Upper Prefumo	10.46	75.8	64.4	64.4	64.1	64.1
Upper SLO City	3.45	87.5	74.4	74.5	74.0	67.2
Upper SLO Creek	17.15	78.6	66.8	66.8	66.8	66.8
Upper Stenner	15.01	80.5	68.5	68.5	68.3	67.2
E B 102	2.29	78.7	66.9	66.9	66.9	66.9
E B 103	4.193	79.3	67.4	67.4	67.4	67.2
E B 104	0.912	80.9	68.7	68.7	68.7	67.2
E B 105	0.837	85.8	72.9	72.9	72.0	67.2
E B 106	3.577	82.1	69.8	69.7	70.4	67.2
E B 107	0.282	85.4	72.6	72.6	71.4	67.2
E B 108	0.127	84.0	71.4	71.4	71.9	67.2
E B 109	2.968	82.7	70.3	70.3	71.0	67.2
E B 110	0.518	89.5	76.1	76.2	73.8	67.2
E B 111	0.458	92.8	78.9	78.9	74.8	67.2
E B 112	1.083	89.4	76.0	75.6	75.6	67.2
E B 113	0.909	89.0	75.6	75.6	75.5	67.2
E B 114	0.041	85.8	72.9	72.9	72.9	67.2
E B 115	1.031	86.3	73.4	73.5	75.5	67.2
E B 117	0.671	86.0	73.1	73.1	73.1	67.2
E B 118	1.054	82.0	69.7	69.7	69.8	67.2
E B 119	0.86	89.0	75.7	76.2	76.2	67.2
E B 202	0.86	86.8	73.8	74.6	73.0	67.2
E B 203	0.448	84.3	71.7	75.5	72.6	67.2
E B 205	0.606	83.7	71.1	73.7	75.4	67.2
E B 206	0.534	86.9	73.9	75.9	72.1	67.2
E B 207	0.085	84.1	71.5	80.3	76.8	67.2
E B 208	0.06	92.9	79.0	79.0	76.7	67.2
E B 209	0.751	84.2	71.6	68.1	78.1	67.2
E B 210	0.58	89.1	75.7	78.1	73.4	67.2
E B 211	0.06	84.0	71.4	80.7	78.2	67.2
E B 212	0.899	88.2	75.0	75.0	75.1	67.2
E B 301	0.904	84.9	72.2	72.6	72.4	67.2
E B 302	0.979	85.7	72.9	72.8	73.1	67.2
E B 304	0.907	85.8	72.9	72.9	72.2	67.2
E B 306	0.08	91.9	78.1	78.6	75.6	67.2
E B 308	0.433	85.9	73.0	73.8	73.6	67.2
E B 309	0.176	90.6	77.0	78.2	74.4	67.2
E B 310	0.049	87.9	74.7	78.7	70.1	67.2
E B 311	0.054	88.4	75.2	79.1	75.0	67.2
E B 312	0.106	88.9	75.5	79.0	72.7	67.2
E B 314	0.368	87.9	74.7	74.7	74.6	67.2
E B 315	0.365	92.9	78.9	78.9	75.4	67.2
E B 316	0.233	83.8	71.3	71.6	70.8	67.2
E B 317	0.238	90.5	76.9	76.7	75.5	67.2

The *initial abstraction* represents the amount of water temporarily stored in puddles, on plant stems, in the soil, etc., before runoff begins. It is related to the runoff curve number but can vary from this relationship depending on how recently the watershed experienced a significant rainfall event. For this study, the initial abstraction was initially assumed to follow an empirical relationship with the runoff curve number as described by **Equation C-1**.

Eq. C-1

$$I_a = 0.2\left(\frac{1000}{CN} - 10\right)$$

Values of initial abstraction ranged from 0.48 to 0.69 in, but were adjusted down 50 percent after model calibration. Because the purpose of the modeling is to predict the runoff from relatively large design storm events, and because the most intense rainfall in the design storm occurs 12 hours after the storm begins, the initial abstraction is usually "filled" long before the most intense design rainfall occurs. This makes initial abstraction a less important variable for our purposes than the curve number. It would be more important if the purpose of the modeling was to predict peak flow rates from less intense, shorter duration storms.

Hydrograph Transformation

The SCS unit hydrograph method was used to transform excess rainfall into runoff at the outlet of any given basin.

Lag time is the difference in time between the center of mass of excess rainfall and the time at which flow from that sub-basin peaks. It is the only required input parameter for the SCS unit hydrograph transformation. Lag time is often calculated as a function subbasin geometry according to the following form:

Eq. C-2

$$T_{lag} = C_t * \left(\frac{(L * L_{ca})}{\sqrt{S}}\right)^m$$

where:

C_t = empirical coefficient
= 24*N where N is a basin roughness coefficient (Nolte and Associates, 1977)
L = the maximum flow length in a basin, in mi.
S = the average slope along the maximum flow length pathway
L_{ca} = the distance from the basin outlet to the centroid
m = lag exponent.

For the sub-basins in the East Branch of San Luis Obispo Creek, lag parameters were taken

from the *City of San Luis Obispo Storm Drain Master Plan* (Boyle Engineering Corporation, 1999). For the remaining basins, two sets of coefficients were used. For the two urbanized basins in the watershed–Upper SLO City and Lower SLO City–coefficients derived by the US Army Corps of engineers for 100% urbanized watersheds in the Tulsa Oklahoma area were used (Boss International, 1999). These are $C_t = 0.59$ and $m = 0.30$. For all other basins outside the East Branch watershed, coefficients derived by Riverside County, California for foothill areas were used. Here, $C_t = 0.72$ (i.e. $N = 0.03$) and $m = 0.38$. Time lag for each of the sub-basins is listed in **Table C-2**.

As part of the model verification process, the unit hydrograph used by George S. Nolte and Associates (1977) was substituted for the SCS Unit Hydrograph Method. The difference in peak flow rates and timing was negligible–on the order of 2-3 percent.

Base Flow

Base flow from each sub-basin was determined by looking at the daily-average flow rates at the stream gauge that operated on San Luis Obispo Creek near Avila until 1986. A conservative estimate was made by assuming that base flow in the creek during a large storm would be similar to the base flow in the creek that was observed over the week following the storm of March 2, 1983. The average base flow for this time period, omitting days when rainfall occurred, was approximately 14 cms (500 cfs). Divided over the upstream area of 207 km^2 (80 mi^2) this gives an average base flow rate of 0.067 cms/km^2 (6.3 cfs/mi^2), which was then applied to each sub-basin.

This base flow rate is significantly higher than the long term average winter-season flow rate in San Luis Obispo creek, and is intended to represent the base flow in the creek during a series of wet storms. It is much greater than any likely wintertime releases from the City of San Luis Obispo Water Reclamation Facility, which discharges into San Luis Obispo Creek downstream from the Prado Road Bridge.

C-1.3 Flow Routing

Runoff from individual sub-basins is routed through the system using the Muskingum-Cunge 8-point routing technique. This technique uses a rough approximation of a channel cross section, including the floodplain, along with representative roughness values, to evaluate the effects of channel and floodplain storage on the flood hydrograph as it passes downstream through the reach.

Highway 101 crosses San Luis Obispo Creek at two locations near the upstream city limits, once just below Cuesta Park, and once just above Cuesta Park. These culverts have been observed to cause ponding upstream of the respective highway embankments during large storms, which could cause a significant amount of attenuation of flood peak flow rates. The backwater behind each of these culverts was modeled using reservoir routing techniques

available in HEC-HMS. A computer hydraulic model was created for each of these culverts using HEC-RAS (as described in Section B-2 of this appendix). A flow versus upstream water surface elevation curve for each culvert was obtained from the model. Elevation versus water surface area curves were obtained from the LIDAR survey flown as part of this project for the lower culvert and from the 1994 City of San Luis Obispo 10-m DEM for the upper culvert. Note that the 10-m DEM is more accurate than the 100-ft DEM currently supported by the City. It was flow by Golden State Aerials in 1994, has a 10 meter horizontal spacing between points, and has a vertical accuracy on the order of 0.6 to 0.76 m (2 to 2.5 ft) (Baragona, pers. comm, 2001). The LiDAR accuracy is on the order of 0.15 m (0.5 ft).

Another important routing area was Laguna Lake in the Prefumo Creek watershed. Laguna Lake was modeled as a reservoir using the Modified Puls method. The stage elevation curve for the lake was obtained from a combination of an existing 10-m Digital Elevation Model (DEM) of the San Luis Obispo Creek watershed and an aerial laser topographinc (LIDAR) survey performed as part of the WMP. (See the WMP for more details). The stage-discharge curve for the reservoir, which empties into lower Prefumo Creek through two 2.13 m x 3.05 m (7 ft x 10 ft) concrete box culverts and one 2.13 m x 4.27 m (7 ft x 14 ft) concrete box culvert under Madonna Road, was obtained by setting up a HEC-RAS backwater model of the culvert and stream system in that area.

Some of Laguna Lake's flood storage volume would likely already be used at the start of a peak 24-hour rainfall event. A conservative starting water surface elevation for the 10-year, 25-year, 50-year, and 100-year storms was obtained by developing a separate simplified rainfall-runoff model of the watershed above the lake and then running an 8-day storm corresponding to the desired recurrence interval through the watershed and lake on an hourly time increment. The simplified model used a constant infiltration rate of 0.13 in/hr, which was reported by George S. Nolte and Associates (1977) to be appropriate for long-term detention analysis. The highest lake elevation from the given design 8-day storm was used as the starting water surface elevation for the 24-hour design storm. The rainfall depth for the 8-day storms was obtained by a statistical analysis of the each year's highest 8-day precipitation total as recorded at the San Luis Obispo Cal Poly rain gage, for the 1948 to 2001 water years. The highest total, 21.8 in, occurred from January 19 to January 26, 1969. The statistical results, as fit to a Gamma probability distribution function, are shown in **Figure C-5**. The precipitation pattern for the 8-day storm was based on the January 19 to 26, 1969 storm as recorded at the Huasna, California gage (the only hourly gage record currently available for that storm). This gage is located approximately 30 km (20 mi) southeast of San Luis Obispo.

C-1.4 Precipitation

The 24-hour design storm precipitation was based on *NOAA Atlas II, Precipitation-Frequency Atlas of the Western United States*. Because of the significant topographic variation within the watershed, two separate 24-hour design storms for each recurrence interval were synthesized, one for the lower portions of the watershed (those basins with a mean elevation below 200 meters) and one for the upper portions (mean elevation 200 meters or greater), based on typical depth-duration-frequency numbers taken from the *NOAA Atlas II* (National Oceanic and Atmospheric Administration, 1973). **Table C-3** lists the depth-duration-frequency values used for developing the design storms. **Figure C-6** shows the basins with mean elevations above 200 meters.

Table C-3. Design Depth-Duration-Frequency Values

For Basins Below 200-m in mean elevation:

	Rainfall (mm) at various durations and frequencies				
Duration	**100-year**	**50-year**	**25-year**	**10-year**	**2-year**
5 min	11.7	10.5	9.3	7.9	5.0
10 min	18.2	16.3	14.4	12.2	7.7
15 min	23.1	20.7	18.2	15.5	9.8
1 hr	40.5	36.3	32.0	27.2	17.1
2 hr	55.2	49.6	45.0	37.7	24.0
3 hr	69.1	62.1	57.4	47.7	30.5
6 hr	101.6	91.4	86.4	71.1	45.7
12 hr	135.9	128.3	115.6	94.0	64.8
24 hr	170.2	165.1	144.8	116.8	83.8

For Basins Above 200-m in mean elevation:

	Rainfall (mm) at various durations and frequencies				
Duration	**100-year**	**50-year**	**25-year**	**10-year**	**2-year**
5 min	12.2	11.2	10.0	8.6	5.6
10 min	19.0	17.4	15.5	13.4	8.7
15 min	24.1	22.0	19.7	16.9	11.0
1 hr	42.2	38.6	34.5	29.7	19.3
2 hr	59.5	54.9	48.2	41.5	27.5
3 hr	76.0	70.5	61.2	52.7	35.2
6 hr	114.3	106.7	91.4	78.7	53.3
12 hr	158.8	146.1	125.7	106.7	73.7
24 hr	203.2	185.4	160.0	134.6	94.0

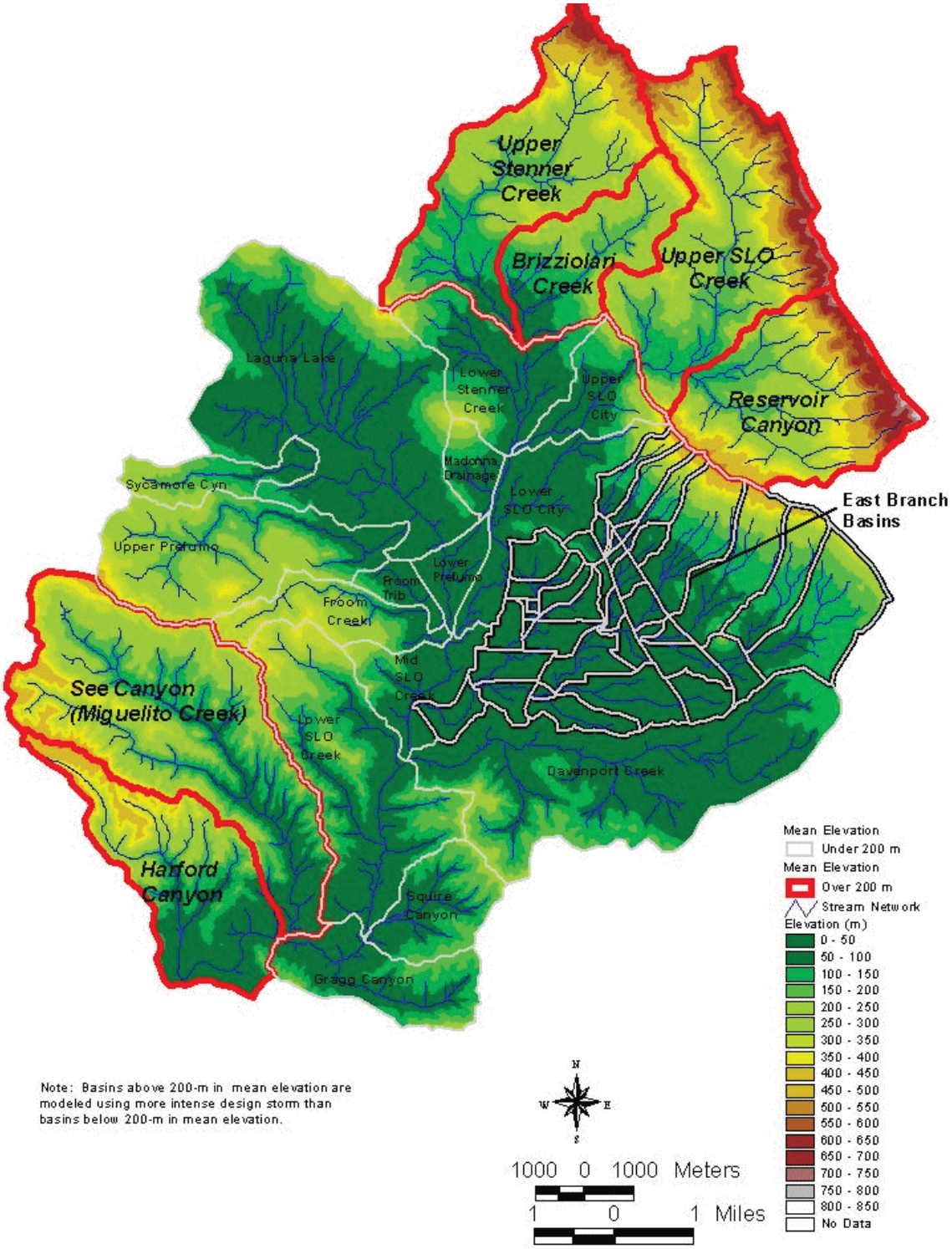

Figure C-6. Higher Intensity Design Storm Locations

Hypothetical design storms generated using this method give precipitation distributions that are appropriate for individual points but not for large areas. For areas much larger than a few square kilometers, the fact that the storm must travel from one portion of the basin to the next prevents the most intense rainfall from occurring all at once. In other words, while it may be raining heavily at point A, at the same time, it is only lightly raining at point B, and the totals at point B may never reach those of point A during that particular storm event. The further apart A is from B, the more pronounced this effect. Because both A and B contribute flow to the lower portions of the creek, flow rates there are lower than if the storm at A was occurring simultaneously at B.

To account for this phenomenon, a correction factor must be applied to the design storms derived using NOAA data. This factor reduces the storm precipitation based on the area of upstream contributory watershed. While there is a fairly simple way to handle this in HEC-1, the current version of HMS does not include this ability. Consequently, we derived four different design storms, each of which would give a conservative approximation of this effect for a selected set of points along the stream system. The depth-area curve used to make the reduction was taken from *NOAA Atlas II* (**Figure C-7**).

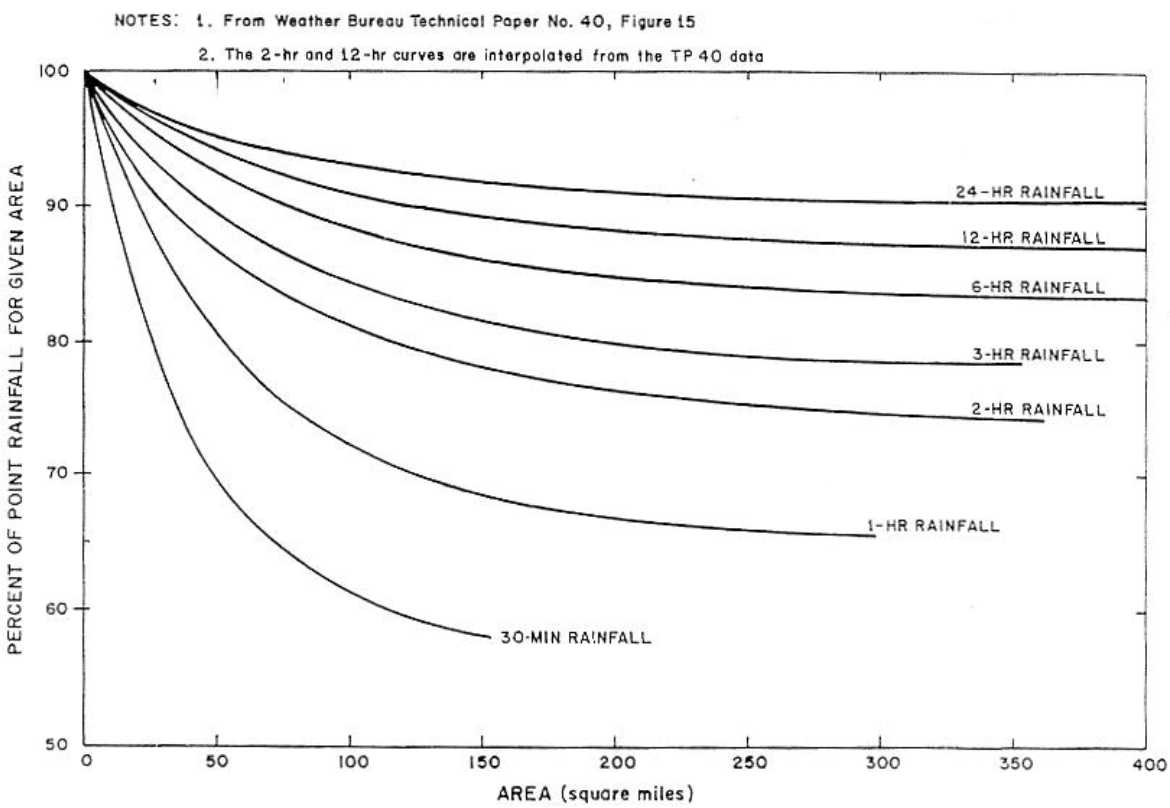

Figure C-7. Depth-Area curves used for developing design storms for larger watershed areas.

The first storm size was set equal to the area of each individual sub-basin. This storm (Storm A) is appropriate along all tributaries of San Luis Obispo Creek before their confluence with San Luis Obispo Creek, as well as for Upper San Luis Obispo Creek before the confluence with Stenner Creek. The second storm (Storm B) was given a size based on the combined area of the Stenner and San Luis Obispo Creek basins above the Stenner/San Luis Obispo Creek confluence (61.8 km^2, 23.9 mi^2). It is appropriate for computing flow in San Luis Obispo Creek from the confluence with Stenner Creek downstream to the confluence with the East Branch of San Luis Obispo Creek. The third storm (Storm C) was given a size based on the combined area of the Main Stem of San Luis Obispo Creek and the East Branch of San Luis Obispo Creek at the Main Stem/East Branch confluence (133.9 km^2, 51.7 mi^2). This storm is appropriate for computing flow in San Luis Obispo Creek from the East Branch confluence downstream to the mouth of the Gragg Canyon tributary. The fourth storm (Storm D) was given a size equal to the entire San Luis Obispo Creek watershed above the confluence with Miguelito Creek (See Canyon, 174.7 km^2, 67.5 mi^2). It is appropriate to use this storm from the mouth of the Gragg Canyon Tributary downstream to the mouth of San Luis Obispo Creek. The depth-area reduction factors used for each storm size are listed in **Table C-4**.

Table C-4. Depth-Area Reduction Factors

Duration	Storm A (12 km^2)	Storm B (62 km^2)	Storm C (133 km^2)	Storm D (175 km^2)
5 min	0.94	0.79	0.69	0.66
10 min	0.94	0.79	0.69	0.66
15 min	0.94	0.79	0.69	0.66
1 hr	0.97	0.88	0.8	0.77
2 hr	0.98	0.91	0.85	0.82
3 hr	0.99	0.94	0.9	0.88
6 hr	0.99	0.96	0.93	0.91
12 hr	1.00	0.96	0.94	0.92
24 hr	1.00	0.97	0.95	0.94

C-2 Hydraulic Model

Project flood management alternatives were analyzed using the U.S. Army Corps of Engineers Hydraulic Engineering Center–River Analysis System (HEC-RAS) version 3.0. HEC-RAS is a one-dimensional hydraulic computer modeling system that is used to predict flood water surface elevations at approximately evenly spaced cross-sections, oriented perpendicular to the predominate flow direction and distributed throughout the modeled reach. The predicted water surface elevations are then compared to the elevation of the top of channel banks and of the floodplain (and buildings) to determine flood break-out points and outline the extent and depth of flood water for various flood flow recurence intervals (i.e. 10-year, 100-year flows).

C-2.1 Data Requirements

The input requirements for the model include stream flow rates, the geometry of various hydraulic structures such as bridges and culverts, topographic information along a set of relatively evenly spaced cross-sections oriented perpendicular to the predominant flow direction, channel roughness estimates (such as flow resistance) along each cross-section, and a water surface elevation at the downstream boundary of the model.

Section C-1 of this appendix describes the rainfall-runoff modeling methods used to define stream flow rates used in this study. Field surveys and as-built drawings were used to define the hydraulic structures such as bridges and culverts.

The topographic information for this project was obtained using LIDAR technology. LIDAR is a system where a laser beam mounted on an aircraft is shot at the ground from the air. The signal produced when the laser beam hits the ground can be used to measure the distance from the aircraft and the ground. This, combined with a global positioning system (GPS) receiver on the aircraft and some post-processing that corrects for signal returns coming from objects not directly on the ground surface can be used to produce a map of ground spot elevations. The raw LIDAR points, which for our survey were spaced approximately 2-meters apart, are then used to create a gridded surface map (at 5-meter spacing for this project) of the channel and floodplain topography.

For this project, the grid produced from the LIDAR was not dense enough to fully characterize the channel bed. Even the 2-meter spacing between raw points was not sufficient in certain locations to fully define the channel. Consequently, a second LIDAR flight, this time with a raw point spacing of less than 1 meter, was performed in the spring of 2000 to densify the channel. Raw points from this and from the original LIDAR survey were used to develop the surface used for hydraulic modeling between channel banks. Outside of the channel banks, the original 5-meter grid was used

Because the post-processing that corrects for vegetation and buildings can remove a significant number of points at some locations where the stream channel bed is obscured by dense vegetation, it was necessary for us to directly inspect the raw point coverage to determine where the LIDAR survey had resulted in a dense point coverage in the channel bed. We drew our cross-sections at locations where the raw data points existed all the way across the stream bed. Also, since bridges can obscure the channel bed from the LIDAR instrumentation, we augmented the LIDAR survey with physical surveys taken in the field at all bridges in the study reach (with the exception of those bridges along the East Branch of San Luis Obispo Creek, where information was taken directly from the HEC-RAS model developed for the area by Boyle Engineering Corporation as part of the Airport Area Specific Plan).

Channel roughness was estimated in the field by comparing published roughness values for various photographed channels with the condition of the local channel (from bank-top to bank-top). Roughness in the floodplain areas outside the stream banks was estimated by creating a map of representative regions using digital orthophotography of the site and coding these representative regions with appropriate values based on published Corps of Engineers guidelines (U.S. Army Corps of Engineers, 2001). Where buildings provide significant obstruction to flood flow, especially through the downtown district of San Luis Obispo and on the east side of Higuera street south of downtown, very high roughness values on the order of 1.0 to 2.0 were used to represent the composite effect of bed roughness across streets and lawns and the obstructing effects of the buildings. Streets in built-up areas that run parallel to the creek channel were coded with low roughness values in order to represent the increased flood flow conveyance these zones provide. **Table C-5** shows the typical roughness values used in the model.

Table C-5. Typical Manning's Roughness Values.

Land Use	Roughness Value
Overbank Areas	
Typical Built up Areas	0.07-0.15
Fields	0.035
Orchard	0.06
Riparian Scrub/Forest	0.09-0.1
Suburban Areas	0.06
Open Streets	0.025
Upland Woodland/Chaparral	0.07
Downtown SLO Commercial Buildings *	1.0-2.0
Stream Channels	
San Luis Obispo Creek Through City	0.045-0.065
San Luis Obispo Creek Below City Limits	0.06-0.07
San Luis Obispo Creek at Avila Golf Course	0.03-0.045
Stenner Creek	0.05-0.065
Brizziolari Creek	0.055-0.06
Prefumo Creek	0.06-0.07

* Downtown commercial buildings were coded with extremely high roughness to effectively block all flow from being conveyed through them. Overbank flow in those areas was allowed to travel down individual streets, which were coded with a roughness of 0.025.

The downstream boundary condition for the model was taken as the highest recorded tide at Port SanLuis, approximately 1.6 km (1 mi) west of the mouth of San Luis Obispo Creek. This water surface elevation was observed on January 18, 1973, during one of the largest storms on record for the region. It is approximately 0.73 meters (2.40 ft) above Mean Higher High Water (MHHW) at this location. A sensitivity analysis performed on this variable showed that the downstream boundary only influenced the model significantly for several hundred meters upstream of the mouth and had no impact on the model above the coffer dam upstream of the Avila Golf Course, about 2 km above the mouth.

C-2.2 Flow Splits

There are several points in the watershed where flow splits out of the main channel and spills across a roadway or berm, leaving the main channel for a significant distance. Specifically, this occurs on Stenner Creek above Foothill Boulevard and again at Murray and Santa Rosa Streets, and on San Luis Obispo Creek across Highway 101 at several locations in the vicinity of Madonna Road. At these specific locations, some of the assumptions made in producing a 1-dimensional model are violated, and a different modeling technique must be used. We used the broad crested weir equation to calculate the amount of flow lost from the main channel at these locations. A separate reach was defined in the HEC-RAS model for the overflow areas until they finally meet up with a modeled creek reach downstream of the breakout point.

C-2.3 Undercity Culvert

In Downtown San Luis Obispo, San Luis Obispo Creek runs for about 370 m (1200 ft) through a completely enclosed structure referred to here as the undercity culvert. According to a U.S. Army Corps of Engineers report (U.S. Army Corps of Engineers, 1985), the culvert has a capacity of 127 cms (4500 cfs). This is not sufficient to pass even a 25-year flow event, according to our hydrology model results. Flow in San Luis Obispo Creek was observed in1973 to split out of the channel upstream of the culvert and to re-enter the channel over 1 km (0.6 mi) downstream, along Higuera Street.

To model the undercity culvert in HEC-RAS, the capacity determined by the Corps of Engineers was assumed to represent the condition just before flow spills out of the channel immediately upstream of the culvert. For flow rates less than the culvert capacity, the culvert was modeled as a rectangular box whose dimensions and characteristics were calibrated so that a 127-cms (4500-cfs) flow just overtopped the channel at the upstream end. For flow rates greater than the culvert capacity, the model was made more stable by simply removing the culvert and modeling an overland flow rate equal to the total design flow minus the 127-cms (4500-cfs) culvert capacity.

C-3 Model Calibration

Regardless of the amount of detail incorporated into the model, calibration against real data must occur before results can be verified and used reliably. Calibration of the hydrologic and hydraulic models was performed using NEXRAD radar rainfall totals and high water marks observed for the storm of March 9 to 11, 1995.

C-3.1 Calibration Storm

One of the challenges of modeling the rainfall along California's Central Coast is the strong orographic influence the Coast Ranges have on precipitation totals. While rainfall for the March 1995 storm was recorded at numerous rain gauges throughout the basin, only six rain gauges in the immediate vicinity of the San Luis Obispo Creek Watershed recorded rainfall on the15-minute (or shorter) time intervals necessary for the hydrology model (**Figure C-8**). The difference between the lowest and highest rainfall total for the March 1995 storm was just over 100% of the lowest gauge total. These gauges were deemed insufficient to fully characterize the magnitude of the storm in certain parts of the watershed, especially where orographic effects would have acted to increase precipitation beyond what the valley floor experienced.

Figure C-9 shows cumulative rainfall at each of six recording rainfall gauges in the watershed. Peak recorded 24-hour totals ranged from 9.39 cm (3.69 in) at the Cuesta Ridge gauge to 21.56 cm (8.49 in) at the Santa Margarita Booster gauge, just north of the northern watershed boundary near the crest of Cuesta Ridge, while peak 48-hour totals ranged from 13.20 cm (5.20 in) at the Cuesta Ridge gauge to 29.76 cm (11.71 in) at the Santa Margarita Booster gauge. The rainfall totals at the county-maintained Cuesta Ridge gauge were significantly lower than at any of the other gauges and are likely in error–especially considering the much higher totals recorded a few miles away at the Santa Margarita Booster gauge. The Cuesta Ridge data were not used in any technical analysis. The next lowest totals were at the SoCal Gas gauge, near the San Luis Obispo Airport, with a 12.12 cm (4.77 in) 24 hr-total and a 14.29 cm (5.62 in) 48-hour total. Because of the wide variability in precipitation totals from gauge to gauge and because of uncertainty in the reliability of the county-maintained Cuesta Ridge gauge (and, by extension, at the other county-maintained gauge at Davis Peak), a more detailed method of modeling rainfall for the March 1995 storm was required.

To provide a more complete picture of rainfall for the March 1995 Storm, archival NEXRAD meteorologic radar information for the time period in question was used to develop a detailed set of rainfall information, on 15-minute time steps, for each basin in the watershed model. The meteorologic analysis, performed by NEXRAIN corporation, involved calibrating radar return information with gauged rainfall intensities so that the NEXRAIN dataset was consistent with gauged information. Gauges outside the San Luis Obispo Creek watershed were used for this rainfall calibration process. Data was first computed on a 2-km by 2-km

grid, and then averaged by sub-basin. Totals for the peak 24-hour period ranged from 16.81 cm (6.62 in) for the Davenport Creek sub-basin to 33.20 cm (13.11 in) for the Harford Canyon sub-basin. A complete 48 hour period was not covered by the NEXRAIN dataset. The entire NEXRAIN dataset can be found in the HEC-HMS hydrology model, which is published on CD along with this document.

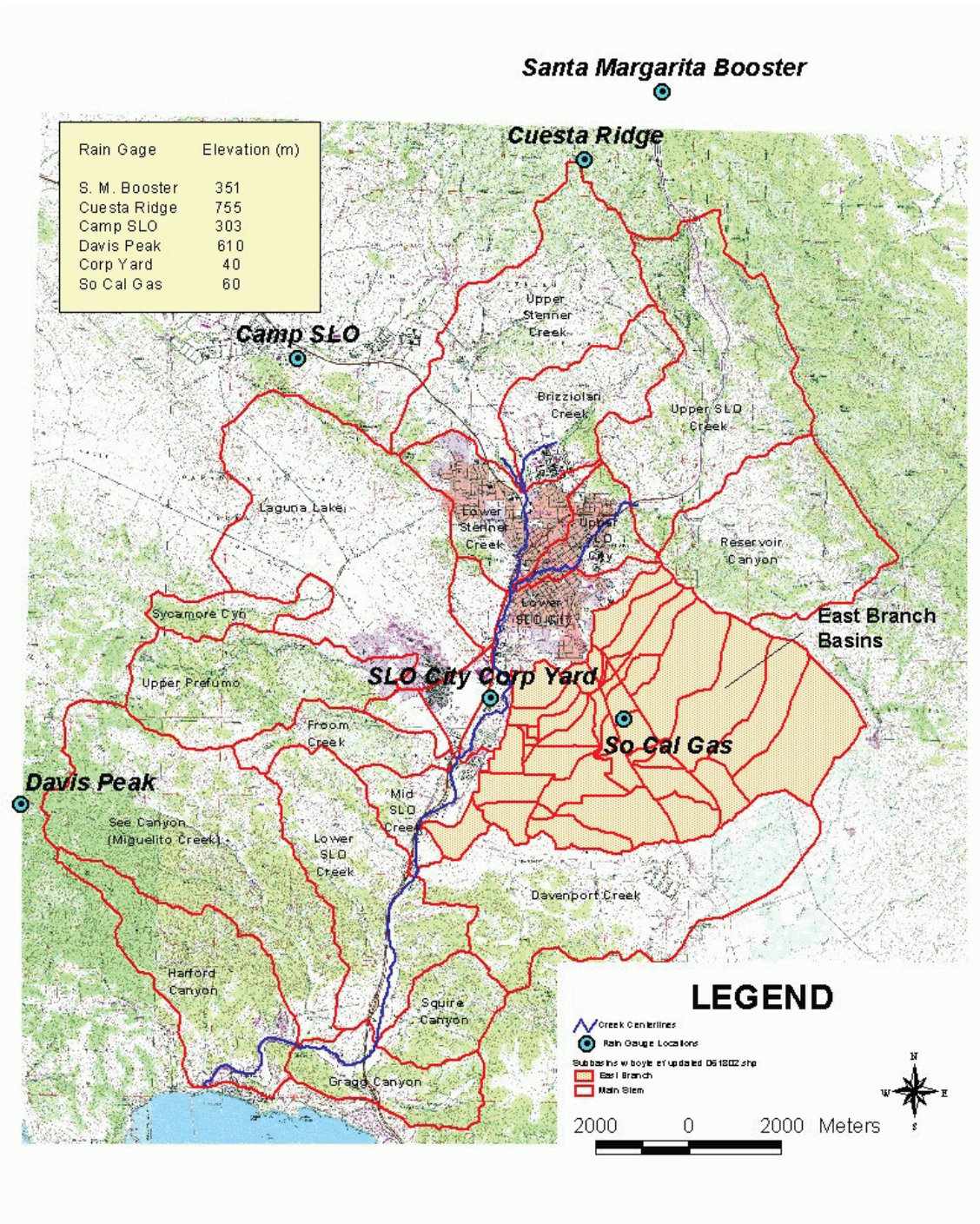

Figure C-8. Precipitation gauge Locations

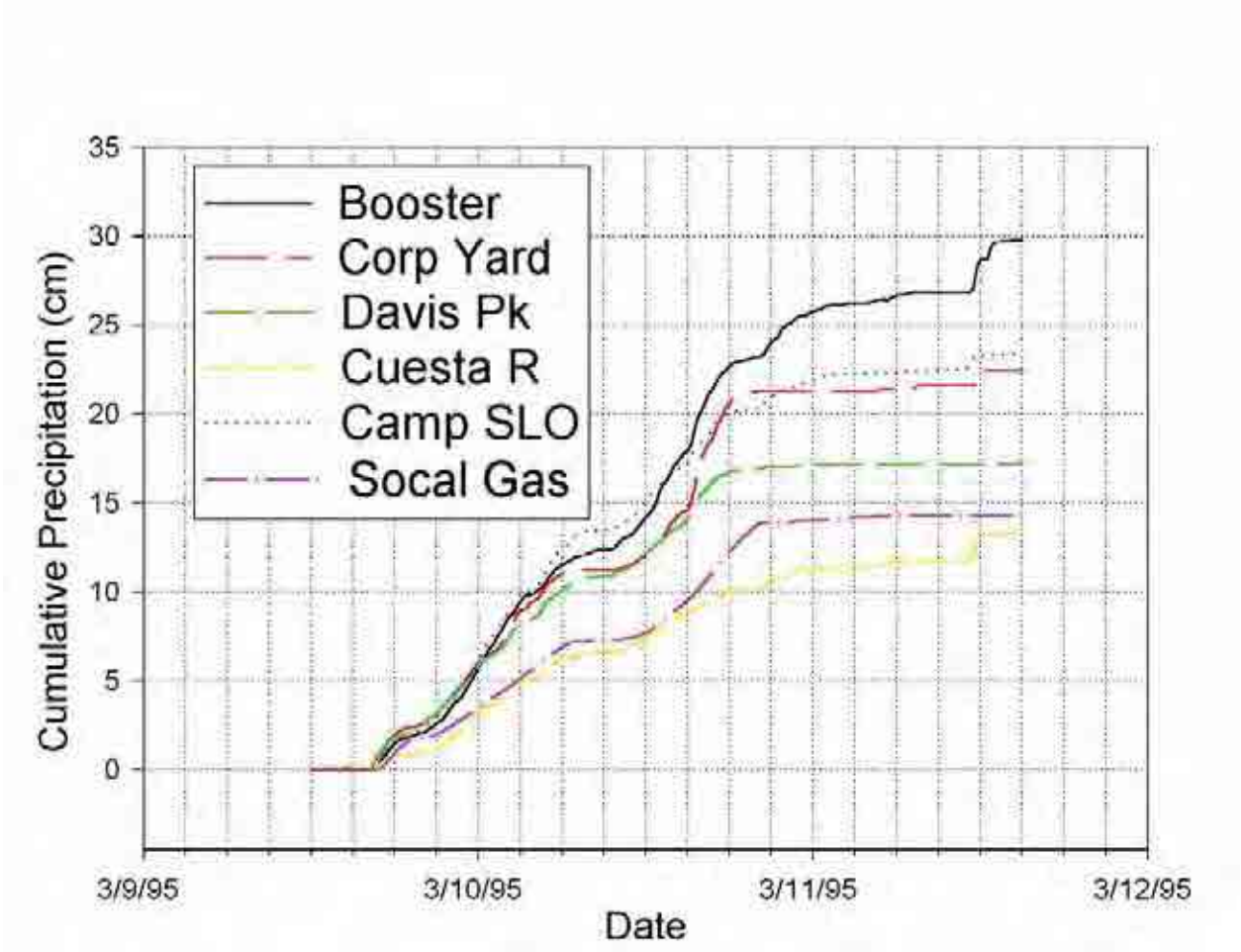

Figure C-9. Rain gauge record, March 9 to 11, 1995.

C-3.2 High Water Marks

Historically, at least two stream gauges existed in the San Luis Obispo Creek Watershed that would have been capable of recording flood peaks. One was located on lower San Luis Obispo Creek near Avila, and the other was located on Upper San Luis Obispo Creek, in San Luis Obispo. Unfortunately, both of these gauges were put out of service in 1992. Since that time, the city of San Luis Obispo has re-installed a gauge on Upper San Luis Obispo Creek. However, there is no gauge record for the 1995 water year.

The best records available for describing the effects of the March 1995 storm are in the form of high water marks surveyed at various points throughout the basin. Some of these high water marks were surveyed immediately after the storm, while others were derived later based on photographs taken near the flood peak. A summary of the available marks is shown in **Table C-6**

.

Table C-6. Hydrology Model Calibration Points.

Observed Mark Location	Source	NAVD 88 Elevation (m)	Reliability [1]	Back-Calculated Flow (m^3/s)	Uncalibrated HMS Flow (m^3/s)	Calibrated HMS Flow (m^3/s)
Sycamore Mineral Springs ~St 3342	Colleen Snyder, Sycamore Employee	9.21-9.36	A	450-500	655	571
Ontario Road ~St 4370	Dan Erdman, County Engineer	9.88	A	490	655	571
Below Sycamore Mineral Springs [2]	Church Water Consultants	multiple points	A	n/a	n/a	n/a
Caltrans Yard, ~St 15646	Caltrans Employee/City Survey	47.67	A	210	293	268
McNamera, ~St 16712	Property Owner/City Survey	53.33	A	325	271	247
Nipomo Bridge, 17431	Photo/LIDAR	58.4	B	140	161	148
Dana Street, ~St 17180	Photo/LIDAR	55.8	B	143	161	148
Upper Stenner Creek @ Radio Tower	Cal Poly Student Survey	N/A	C	62	64	58
Stenner Creek 300m above Nipomo	Cal Poly Student Survey	N/A	C	78	118	106
Brizziolari Creek Above Cal Poly	Cal Poly Student Survey	N/A	C	26	33	30

[1] Reliability is used here to denote the quality of the survey used to determine the high water mark. For an "A" rating, the datum o the mark must be correctly known and have been surveyed professionally. For a "B" rating, the location of the mark is precisely known, bu the elevation of the nearest surface visible on the LIDAR survey is used as a vertical datum. Neither the precise location nor elevatio of the "C" marks is known. These were taken from a senior project prepared by a Cal Poly student in 1995. Some manipulatio of the data in the student report was required to allow the data to be used for this study

[2] Points surveyed by Church Water Consultands were too numerous to back-calculate flows individually. They were used as model validation. See Figure B-1

C-3.3 Calibration Technique and Results

Because no reliable stream gauge data was available for the March 1995 storm, the best way to check the results of the rainfall-runoff model against reality was to use the hydraulic model to back-calculate flow rates from recorded high water marks, and to then check whether the rainfall-runoff model produced these flow rates for the March 1995 storm. This raises the question of how we could computed reliable flow rates using the hydraulic model that itself had not been checked against reality. The reality check for the hydraulic model came from trying to make high water marks for any given region consistent with one another. This was accomplished by adjusting channel roughness assumptions until the high water marks produced consistent flow rates.

Without any calibration, the rainfall-runoff model gave fairly high runoff results **(Table C-6).** To achieve the best fit possible, the SCS curve number parameter was reduced by 15% across the entire model. The 15% reduction was applied to all basins of all watershed models, including the pre-European settlement model, the 1965 conditions model, the existing conditions model, and the future conditions model.

Figure C-10 shows the position of a set of high water marks taken on San Luis Obispo Creek near the lower San Luis Bay Drive Bridge with respect to the modeled water surface elevation for the March 1995 flow (after calibration). **Figure C-11** shows observed and calibrated high water model results on San Luis Obispo Creek near the confluence with Stenner Creek. The agreement between the high water marks from this data set and the modeled water surface is relatively good. The most error between the predicted and observed water surface within the City of San Luis Obispo occurred at the Marsh Street Bridge, where the observed flood elevation was approximately 0.6 m (2 ft) above the modeled flood elevation. The most likely reason for this discrepancy is the tendency for the Marsh Street Bridge to collect debris during a large storm event. Due to their unpredictable nature, the HEC-RAS model does not account for debris blockages (In general, bridges known to be

prone to debris blockage should be monitored during large storm events, and any debris blocking the bridge opening should be removed.) It is likely that debris raised the flood elevation at the Marsh Street Bridge above the level that would have occurred if no debris had been present.

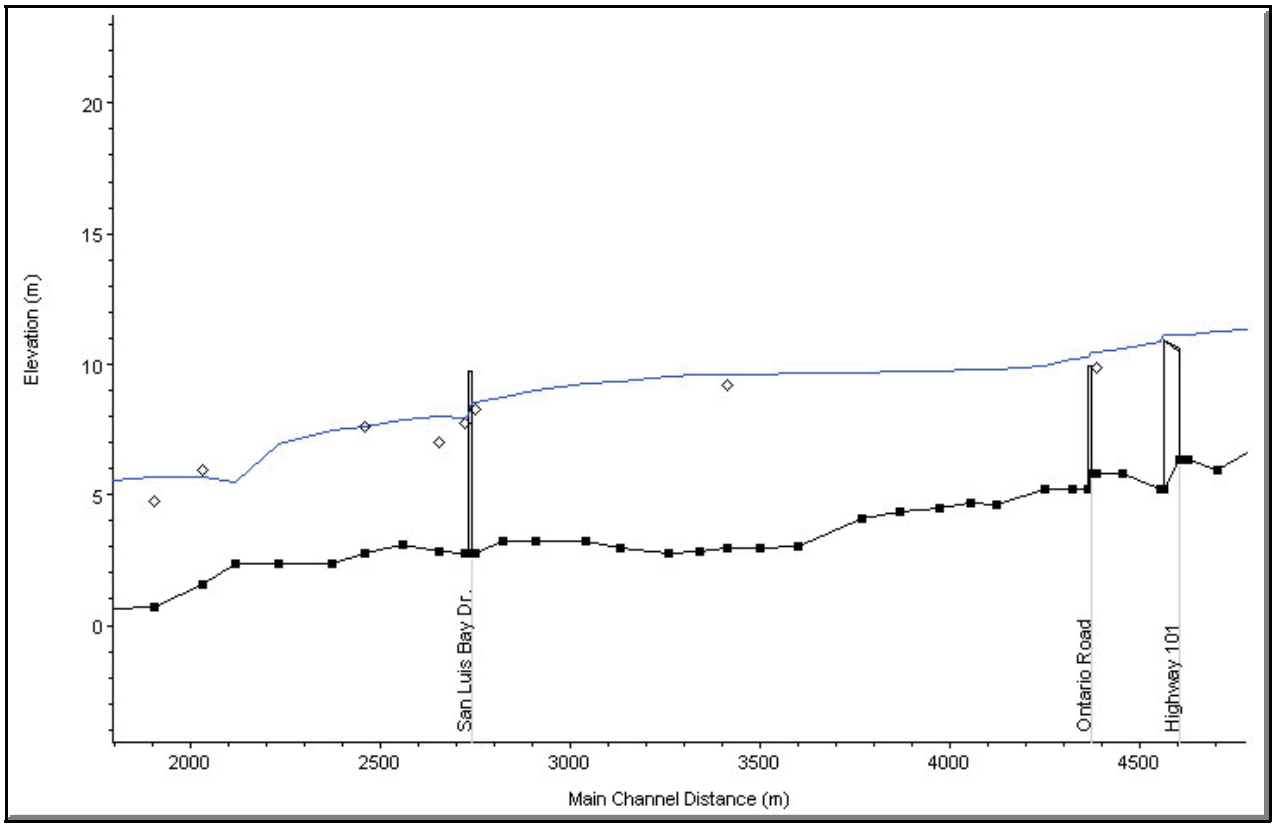

Figure C-10. Observed high water marks (black diamonds) compared with calibrated modeled water surface (blue line) for March 11, 1995 storm, near Avila Beach.

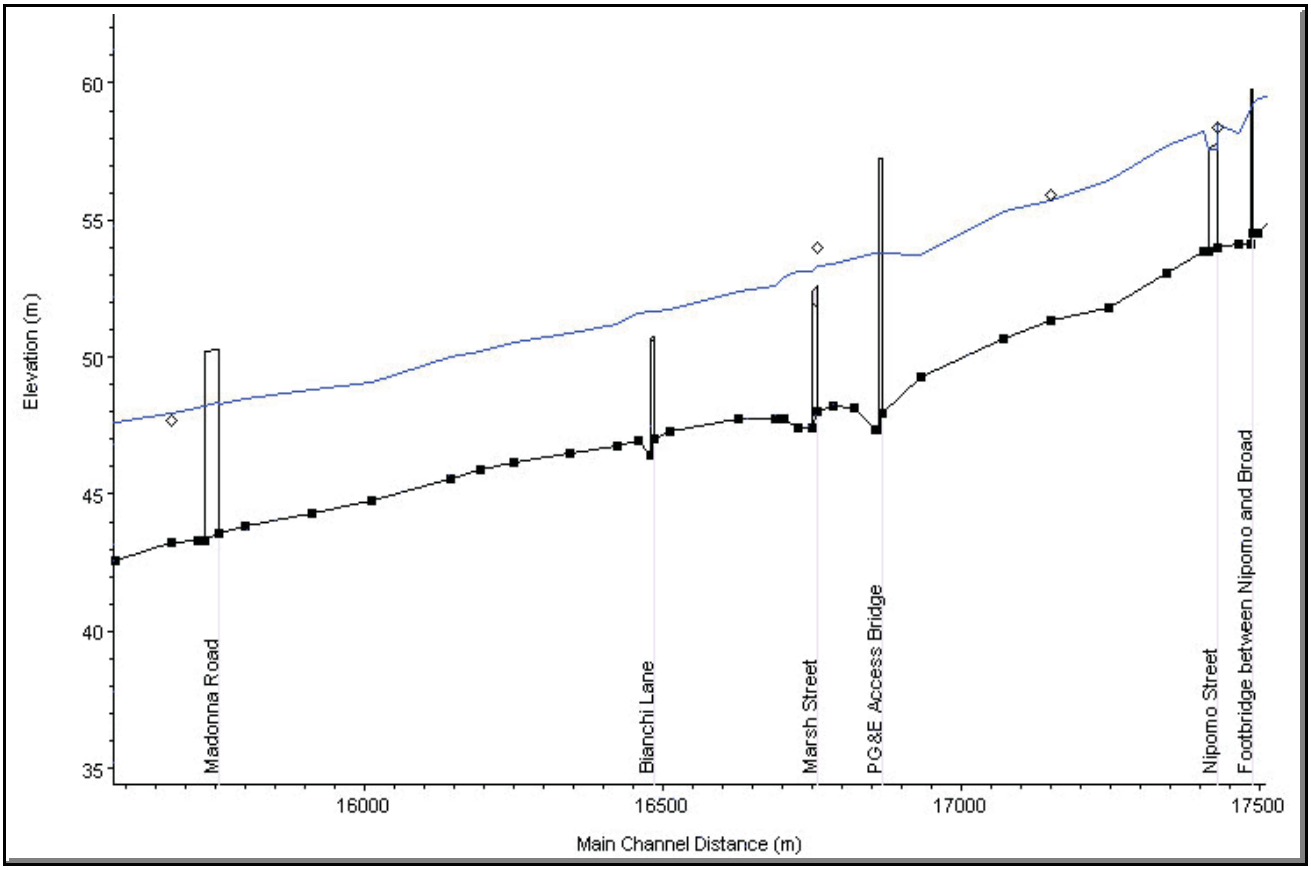

Figure C-11. Observed High Water Marks (black diamonds) compared with calibrated modeled water surface (blue line) for March 11, 1995 storm, within San Luis Obispo City Limits.

C-4 Results of the Hydrologic and Hydraulic Modeling

The results of the hydrologic model at various locations in the watershed are shown in **Table C-7**. Modeled water surface elevation profiles are included in at the end of this Appendix and are numbered **CP-1** (Appendix C/Profile #) through **CP-24**.

One of the objectives of this study was to evaluate the impact that development within the upper areas of the watershed has had on flood flow rates lower in the watershed. Typically, increasing impervious surface areas within a watershed increases flood risk downstream. To test this, design precipitation events were run through each of the four models (i.e. prehistoric, historic 1963, existing, and general plan buildout conditions). The results are shown in **Table C-8**. These results show very little change in peak flow rates from prehistoric conditions to existing conditions. This is primarily due to the presence of the two crossings of Highway 101 over San Luis Obispo Creek at Cuesta Park, above San Luis Obispo. The highway embankment at these locations acts as a dam, holding back the highest storm peaks. Were it not for the highway, increases in impervious surface throughout the watershed would likely have caused an increase of between about 4 and 7 percent,

depending on recurrence interval and location in the watershed. Most of this effect likely occurred fairly early in this century, at least before the 1960's. However, the construction of the two Highway 101 crossings of San Luis Obispo Creek at Cuesta Park has essentially negated this increase.

Table C-7. Selected Hydrology Model Results for Existing Watershed Conditions

				Flow Rates (m^3/s)					
Creek	**Station**	**Description**	**Storm Size**	**Q100**	**Q50**	**Q25**	**Q10**	**Q2**	**1995 Flow**
SLO	20627	Cuesta Park	A	176	166	147	123	71	136
SLO	19319	At California Boulevard	A	190	179	160	133	79	148
SLO	16935	At Stenner Creek Confluence	B	354	319	274	220	119	247
SLO	15583	At Meadow Creek Confluence	B	378	341	292	231	127	268
SLO	12148	At Prefumo Creek Confluence	B	433	389	333	258	142	323
SLO	11897	At Froom Creek Confluence	B	444	398	342	264	145	333
SLO	10182	At E. Branch Confluence	C	538	476	412	309	165	468
SLO	9159	At Davenport Creek Confluence	C	596	525	455	338	179	516
SLO	4929	At Squire Creek Confluence	C	624	548	478	353	185	559
SLO	4554	At Gragg Canyon Confluence	C	632	555	485	357	186	570
SLO	3131	At Miguelito Creek Confluence	D	671	589	506	374	194	639
SLO	214	At Harford Canyon Confluence	D	686	603	513	376	191	669
Prefumo	1906	Laguna Lake Outlet	A	58	48	40	28	17	49
Prefumo	1385	At Drainage from Madonna Plaza	A	60	50	42	29	18	51
Prefumo [1]	432	At Calle Joaquin	A	71	62	51	35	21	56
Stenner		Above Brizziolari Creek	A	106	93	76	59	30	58
Stenner	2449	At Brizziolari Creek Confluence	A	166	146	120	93	48	85
Stenner	976	At Garden Creek Confluence	A	206	181	149	115	58	106
Brizziolari	n/a	Entire Sub-basin	A	70	62	51	40	21	30
Orcutt	2416	At Orcutt Road	A	6.2	5.5	4.6	3.4	1.7	2.8
Orcutt	1079	At Broad Street	A	12	11	9	6.9	3.5	5.2
Orcutt	583	At Confluence with Acacia Creek	A	15	14	11	8.6	4.3	6.6
Acacia	1877	At Orcutt Road	A	11	10	8.2	6.2	3.2	5.9
Acacia	1593	At Broad Street	A	40	35	29	22	11	22
Acacia	489	At Confluence with East Branch	A	42	37	30	23	11	23
East Branch SLO	6685	Above Acacia Creek Confluence	A	115	101	83	61	29	81
East Branch SLO	5984	Below Acacia Creek Confluence	A	154	136	112	83	40	107
East Branch SLO	4040		A	178	157	130	96	47	116
East Branch SLO	3425	Below Airport Tributary Confluence	A	186	164	136	100	49	120
East Branch SLO	1834	Below Tank Farm Creek Confluence	A	212	187	155	114	56	136
East Branch SLO	740	At Mouth	A	215	189	158	116	57	139

[1] Includes "Froom Tributary" basin, which during low flow drains to Froom Creek.
Inclusion of this basin results in conservative flow estimate where Prefumo Creek crosses under U.S. 101.

A more detailed analysis of these results and their flood management implications is available in

Table C-8. Impact of Changes in Land Use and Watershed Development on Flow Rates

	Flow Rates (m^3/s)		% Change from Pre-Settlement	
Estimated Pre-Settlement Conditions	**Q10**	**Q100**	**Q10**	**Q100**
SLO Creek Below Stenner Conf.	235	430	n/a	n/a
SLO Creek at Mouth	360	690	n/a	n/a
1963 Conditions				
SLO Creek Below Stenner Conf.	218	352	-7.2%	-18.1%
SLO Creek at Mouth	375	685	4.2%	-0.7%
Existing Conditions				
SLO Creek Below Stenner Conf.	220	354	-6.4%	-17.7%
SLO Creek at Mouth	376	686	4.4%	-0.6%
Existing Conditions, Discounting Detention at 101[1]				
SLO Creek Below Stenner Conf.	248	448	5.5%	4.2%
SLO Creek at Mouth	385	726	6.9%	5.2%
General Plan Buildout Conditions [2]				
SLO Creek Below Stenner Conf.	220	354	-6.4%	-17.7%
SLO Creek at Mouth	378	685	5.0%	-0.7%

[1] Currently Highway 101 at Cuesta Park provides some flood protection. These runs ignore this protection.

[2] Assumes Highway 101 at Cuesta Park is in its existing configuration. It may be possible to augmen the protection provided by the highway embankment. See Flood Management Alternatives Section

Section 5.4 of the Waterway Management Plan Report.

C-5 Comparison with Previous Studies

One of the motivating factors for the San Luis Obispo Waterway Management Plan (WMP) has been the frequent flooding that has occurred on San Luis Obispo Creek. It is believed that previous studies have inadequately predicted the relatively frequent occurrence of flooding in the area, especially in the Mid-Higuera area and along Stenner Creek.

C-5.1 1974 Corps of Engineers/Nolte/FEMA Study.

Since the 1970's, the definitive study on flow in the San Luis Obispo Creek watershed has been the 1974 U.S. Army Corps of Engineers floodplain study of San Luis Obispo Creek (U.S. Army Corps of Engineers, 1974). This study was updated in 1977 by George S. Nolte and Associates to predict flow rates at recurrence intervals other than the 100-year event. The Nolte study was used by FEMA for its Flood Insurace Study of the area (FEMA 1978).

The Corps/Nolte/FEMA study involved the construction of a theoretical watershed model similar in nature to that used for the current study. As in the current study, the Corps/Nolte/FEMA study split the watershed into a set of small sub-basins. A theoretical equation was used to predict rainfall losses for each sub-basin. Then a unit hygrograph was used to translate the rainfall excess (that not lost using the loss equation) into a runoff hydrograph. The hydrograph was then routed downstream from the outlet of each sub-basin in a similar way to the model described in this report.

The precipitation model used in the Corps/Nolte/FEMA study was very different than that used in the WMP, however. Instead of modeling a specific design precipitation event at each recurrence interval (i.e. a 10-year or 100-year 24-hour design storm) as was done for the WMP, the Corps/Nolte/FEMA study used an actual recorded rainfall event (in this case, the January 19, 1973 event) to define a storm that theoretically represented the maximum precipitation possible for a given part of the watershed. The process involved defining precipitation contours for the 1973 event, which was centered over the Irish Hills near the Prefumo Creek watershed, and then developing a way to re-center the storm over any given basin. The temporal distribution for the storm was determined from two recording rain gauges and was computed on 15-minute intervals.

The runoff occurring from the theoretical maximum possible precipitation event (which was derived from but different than the 1973 event), when centered over a given basin, was termed the standard project flood (SPF). The SPF has no direct relationship with a given recurrence interval. To develop such a relationship, a second watershed model was developed for the nearby Arroyo Grande Creek watershed, which at that time had a gauge with a 28-year record (prior to the construction of Lopez Dam) that had been analyzed statistically to determine a 100-year flow rate. At that gauge, the statistically-determined 100-year flood event was 63% of the SPF. This fraction was then assumed to apply to San Luis Obispo Creek watershed. The 100-year flow rate for any given basin in the San Luis Obispo Creek Watershed was found by multiplying the SPF for that basin by 0.63.

To determine flow rates at more frequent recurrence intervals, the Nolte study used a regional regression analysis of six nearby watersheds to define a set of regional flood frequency curves, which state the ratio of the 50-, 25-, and 10-year events to the 100-year event as a function of drainage area. These relationships were used to define flow rates at recurrence intervals other than the 100-year event in the San Luis Obispo Creek Watershed.

Flow rates from the Nolte study were used by FEMA to develop a backwater hydraulic model of San Luis Obispo Creek and tributaries within the City Limits of San Luis Obispo. The results of this model were used to develop the current FEMA flood plain map. This model was very similar conceptually to the HEC-RAS model employed by the current study

(WMP) to develop flood water surface elevations and flood plain information. However, advances in computer technology allow the current (WMP) model to use additional, more tightly spaced cross sections and more detailed floodplain topography and roughness information.

C-5.2 1999 U.S. Army Corps of Engineers Statistical Analysis of Local Stream Gauges

Serious flooding throughout the Central Coast of California in 1995 and 1997 prompted the U.S. Army Corps of Engineers to perform a flood frequency study at certain local gauges in 1999 as part of a larger study of San Luis Obispo and Monterey Counties. This study applied traditional flood frequency statistical analysis at several gauges in the watershed. The results are listed in **Table C-9**.

C-5.3 1999 U.S. Army Corps of Engineers Regional Statistical Analysis

After performing their analysis of specific gauges (Section B-5.2), the U.S. Army Corps of Engineers performed a regional flood frequency analysis using stream gauge data at various locations along the Central California Coast. This study resulted in a set of equations that predict flow rates at given recurrence intervals as a function of drainage area, mean annual rainfall, length of time of concentration, and length of "blue line" streams within the sub-basin on the appropriate USGS quadrangle map (U.S. Army Corps of Engineers, 1999b). The results at a few select points within the San Luis Obispo Creek watershed are listed in **Table C-9**. In general, this method resulted in lower flow rates than the analysis of specific gauges within the San Luis Obispo Creek watershed (Section B-5.2).

C-*5.4 Discussion of Differences From Previous Studies*

While the WMP model generally shows higher flow rates at all recurrence intervals than the previous studies (with the possible exception of the Corps of Engineers individual gauge analysis), the most important differences occur for frequent (i.e. 25-year or shorter) recurrence interval storms (**Table C-9**). The WMP model shows on the order of twice the flow rate from the Corps/Nolte/FEMA model at the 10-year event, while the difference is far less at the 100-year event. The one exception to the WMP results being higher than the Corps/Nolte/FEMA results is on San Luis Obispo Creek just above the confluence with Stenner Creek (point 2 in Table B-9). This occurs because the Corps/Nolte/FEMA model did not consider the detention provided by the Highway 101 culverts at Cuesta Park (Section C-1.3). In general, since the current model results in higher flow rates for frequent storms than the previous USACE/Nolte/FEMA model, its use will result in a more conservative flood management design.

The Corps of Engineer's individual gauge analysis is difficult to interpret. It shows a greater flow rate at the 100-year event on Stenner Creek than on lower San Luis Obispo Creek near Avila. In general, its results are higher than the current hydrology model results except at the gauge near Avila. It appears likely that the Avila Gauge may have mis-recorded high flow

rates and should be dismissed. The fact that the Avila gauge was used by the Corps of Engineers for its regional regression analysis could help explain why the regional regression analysis predicts lower flow rates than either the current model or the Corps/Nolte/FEMA model. Additionally, work Questa performed for the County of San Luis Obispo (Questa Engineering Corporation, 2000) identified an error in one of the other gauge records used in the Corps gauge analysis (The Main Street gauge on Santa Rosa Creek in Cambria appears to have missed the peak of the crucial March 1995 flood event). Because of the uncertainties associated with the gauge record, further application of the 1999 Corps of Engineers hydrology studies to the San Luis Obispo Watershed should be undertaken only cautiously.

In summary, the WMP model generally predicts higher flow values than the other studies. Its use would consequently be expected to result in relatively conservative flood management designs. In any case, the development and calibration procedures for the WMP model used the most current technology and data available and should represent the most accurate and complete flow and flood plain information of any of the studies reviewed here.

Table C-9. Comparison of Modeled Flow Results with Other Studies

		Upstream Drainage Area		10-Year Flow		100-Year Flow	
		sq. mi	sq. km	m³/s	cfs	m³/s	cfs
Questa/Zone 9 Model							
1	SLO Creek Above City Limits (above Res. Cyn)	6.6	17.1	64	2300	117	4100
2	SLO Creek Above Stenner Creek Confluence	12.8	33.2	133	4700	190	6700
3	Stenner Creek Above Brizziolari Creek Confluence	5.8	15.0	59	2100	106	3700
4	Stenner Creek Above SLO Creek Confluence	11.1	28.7	115	4100	206	7300
5	SLO Creek At Squire Canyon	70	181.3	353	12500	624	22000
FEMA Flood Insurance Study							
1	SLO Creek Above City Limits (above Res. Cyn)	–	–	–	–	–	–
2	SLO Creek at Higuera Street (above Stenner conf.) [1]	12.6	32.6	71	2500	221	7800
3	Stenner Creek Above Brizziolari Creek Confluence [1]	5.7	14.8	31	1100	102	3600
4	Stenner Creek at Broad Street (above SLO conf.) [1]	10.8	28.0	59	2100	190	6700
5	SLO Creek above See Canyon [2]	64.6	167.3	119	4200	561	19800
Corps of Engineers Analysis of Individual Gage Record [3]							
1	SLO Creek "Near San Luis Obispo" (above Res. Cyn) [3]	5.27	13.6	46	1640	167	5900
2	SLO Creek Above Stenner Creek Confluence	–	–	–	–		–
3	Stenner Creek at Cal Poly (above Briz. conf.) [3]	5.5	14.2	76	2680	282	9950
4	Stenner Creek Above Confluence with SLO Creek	–	–	–	–		–
5	Lower San Luis Obispo Creek Near Avila [3]	67.7	175.3	146	5140	272	9620
Corps of Engineers Regional Regression Equation							
1	SLO Creek "Near San Luis Obispo" (above Res. Cyn) [3]	5.27	13.6	–	–	130	4608
2	SLO Creek Above Stenner Creek Confluence [4]	13.03	33.7	42	1500	136	4800
3	Stenner Creek at Cal Poly (above Briz. conf.) [3]	5.5	14.2	–	–	210	7427
4	Stenner Creek Above SLO Creek Confluence [4]	11.01	28.5	40	1400	108	3800
5	Lower San Luis Obispo Creek Near Avila [3]	67.7	175.3	–	–	485	17131

[1] Federal Emergency Management Agency. Flood Insurance Study: City of San Luis Obispo, California. October 1978.

[2] George S. Nolte and Associates. Flood Control and Drainage Master Plan for the San Luis Obispo Creek Watershed. 1977.

[3] U. S. Army Corps of Engineers, Los Angeles District. Part II Discharge-Frequency Analysis: Report on Hydrologic Analysis of San Luis Obispo, Santa Rosa, and Arroyo Grande Creeks.October 1999.

[4] U. S. Army Corps of Engineers, Los Angeles District. Part I Regional Discharge-Frequency Analysis: Interim Report on Hydrologic Analysis of San Luis Obispo, Santa Rosa, and Arroyo Grande Creeks. June 1999.

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APPENDIX D

PROJECT ALTERNATIVES

This Appendix discusses project alternatives that were reviewed and evaluated by the Zone 9 Advisory Committee in selecting the recommended or Preferred Project. As with the Preferred Project, project alternatives consist of a functional grouping of a number of discrete project actions that would address local flooding problems separately along various reaches of SLO Creek. Three groupings of projects or alternatives were evaluated from a technical, environmental, and cost perspective. They include:

- **Alternative 1- Design Modifications to the Preferred Project**. A technically and financially viable Design Alternative that could be constructed at a lower cost than the preferred project, but that has greater environmental impacts.

- **Alternative 2- Low Cost/Low Impact Alternative** that would provide limited additional flood protection.

- **Alternative 3- Projects Not Considered Feasible and Not Evaluated Further**. This consists of project components that were not considered technically or financially feasible and were not evaluated further.

In addition to these alternatives, non-structural flood control options are discussed in this section.

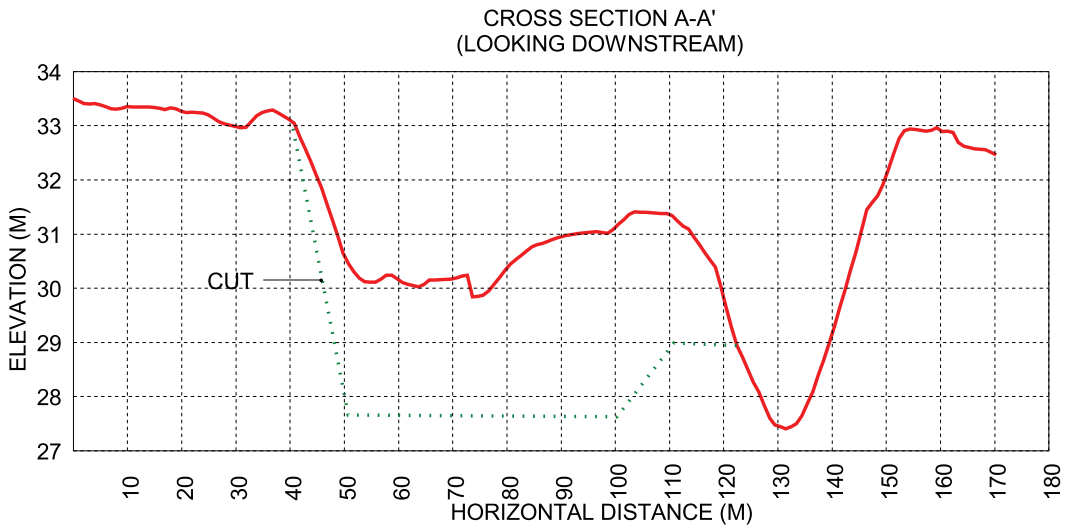
D1.0 Alternative 1- Design Modifications to the Preferred Project

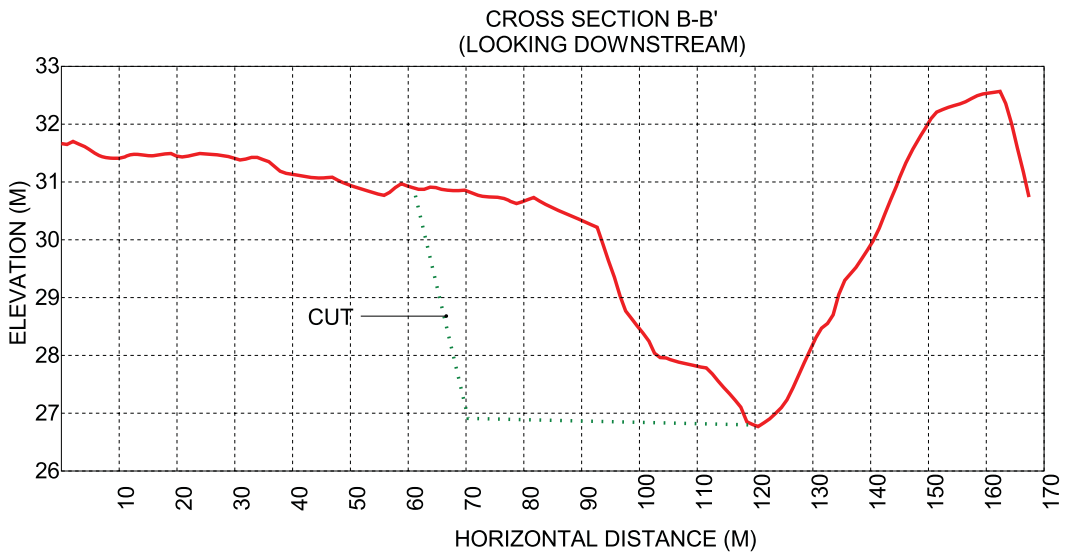
Alternative 1 (**Figure D-1)** represents structural projects that would provide a similar or higher level of flood protection as compared to the Preferred Project, but channel environment disturbance would be higher. Construction costs would generally be lower, because less land would need to be purchased for channel widening than the Preferred Project with bypass channels. This alternative evolved from discussions and review of the preferred project by the Zone 9 Advisory Committee. It represents an alternative that could be constructed with less overall costs than the Preferred Project, but with higher environmental impacts.

All of the main elements of the Preferred Project would be included in Alternative 1 (Stenner Creek bridge replacement, Cuesta Park detention enhancement, channel maintenance in Mid-Higuera); however, several of the components have modified designs that may differ in their environmental impacts and in costs of construction, as compared to the Preferred Project. Modified design components include:

- **Widen SLO/Prefumo Creek Confluence** near Los Osos Valley Road, just below the confluence of Prefumo and San Luis Obispo Creeks, to prevent flow from backing up onto highway 101 and into Prefumo Creek on the west side of the Highway, (instead of the bypass channel of the Preferred Project).

- **Channel Widening Between Cemetery above Elks Lane and WTTP below Prado Road.** This would include replacement of the Preferred Project bypass channel with a channel-widening project from above Elks Lane downstream to





city of san luis obispo	**LOVR Design Alternative** **SLO Phase II Waterway Management Plan** QUESTA ENGINEERING CORPORATION	**Figure** **D-1**

Prado Road. The widened channel would be designed to provide 100-year protection for the adjacent mainly undeveloped floodplain and would prevent flow from spilling across Highway 101 and flooding the historic floodplain on the west side of the highway at the 100-year event.

- **Floodplain Excavation in Mid-Higuera Area.** This would include a floodplain bypass channel excavation within the Mid-Higuera Business District, similar to the Preferred Project. However, the initial channel excavation work just below the Marsh Street Bridge would occur on the east bank downstream to just below the Bianchi Lane Bridge, and not on the west side at the Madonna Company construction yard**.**

D.1.1 Widen SLO/Prefumo Creek Confluence

This design alternative to the Preferred Project would widen San Luis Obispo Creek near LOVR to increase local capacity and reduce backwater flooding on Prefumo Creek and Highway 101. This project would provide protection up to the 100-year flood. It would be constructed instead of the bypass channel proposed as the Preferred Project, as a lesser-cost alternative. The existing arch culvert where LOVR crosses SLO Creek is sufficient to pass the 100-year flood, so no new bridge would be required.

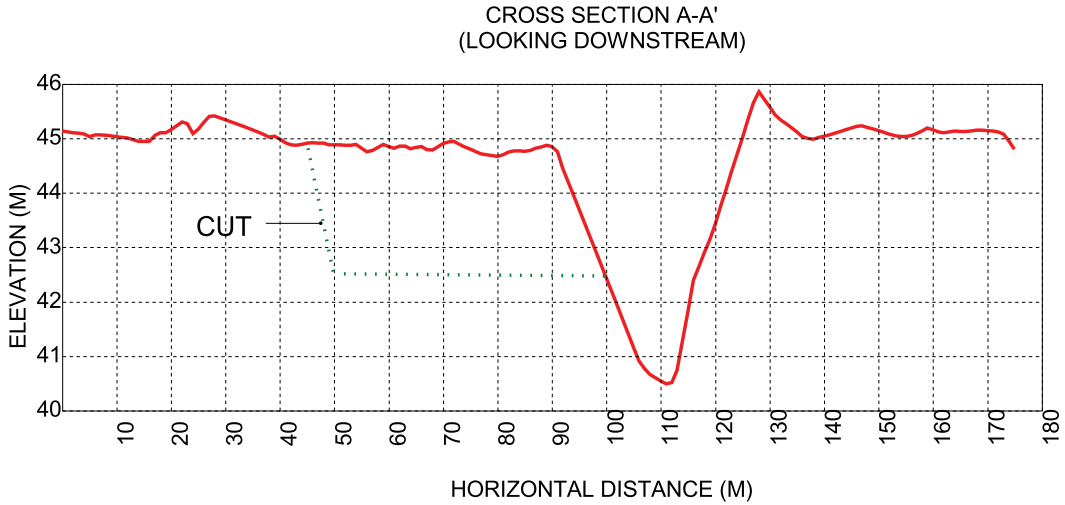
Channel widening would focus on the east bank, and would extend downstream from the LOVR crossing of SLO Creek about 250 meters. The upper channel would be widened and deepened at the location of the existing bypass channel (see Section A-A' in Figure D-1). The bed of the bypass channel would be near the existing streambed.

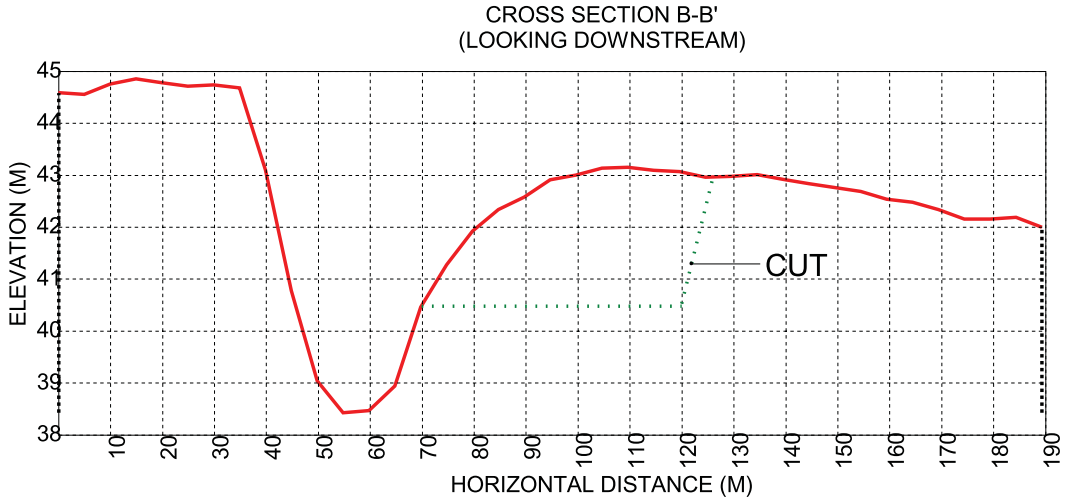
Additional lowering of the water surface elevations in Prefumo Creek would also be achieved in this reach by managing the existing dense vegetation, as in the Preferred Project. This would involve thinning and limbing up the willows, and inter-planting with single trunk species such as sycamores and cottonwoods. The work would be focused on Prefumo Creek below Calle Joaquin. Replacing the Prefumo Creek culverts under Highway 101 and the Highway 101 onramp are also included as part of this project, as with the Preferred Project.

D.1.2 Channel Widening Between Cemetery above Elks Lane and WTTP below Prado Road

Increased flood flow conveyance to meet an increased Design Flow goal of a 100-year recurrence interval flood would be provided on SLO Creek by channel enlargement, generally on the east bank (**Figure D-2**). An in-channel bench or floodplain terrace would be constructed about 1/3 of the way up the bank, just above the 2-year flow line, or OHW. The floodplain terrace would be planted to native riparian trees and shrubs.

This Design Flow is greater than the proposed DDM Design Flow of 50-year





city of san luis obispo	**Elks Lane Design Alternative** **SLO Phase II Waterway Management Plan** QUESTA ENGINEERING CORPORATION	**Figure** **D-2**

protection. However, the 100-year Design Flow can be achieved through this reach with little increase in project cost over the 50-year Design Flow, when using a channel terrace excavation approach.

The primary difference in cost and environmental impact between a 50-year and a 100-year design are the replacement of the Prado Road bridge and slightly greater excavation width (and volume), Since the additional excavation would occur on floodplain uplands (grasslands), there is also little increase in impacts to the riparian corridor, as compared to a 50-year terrace project

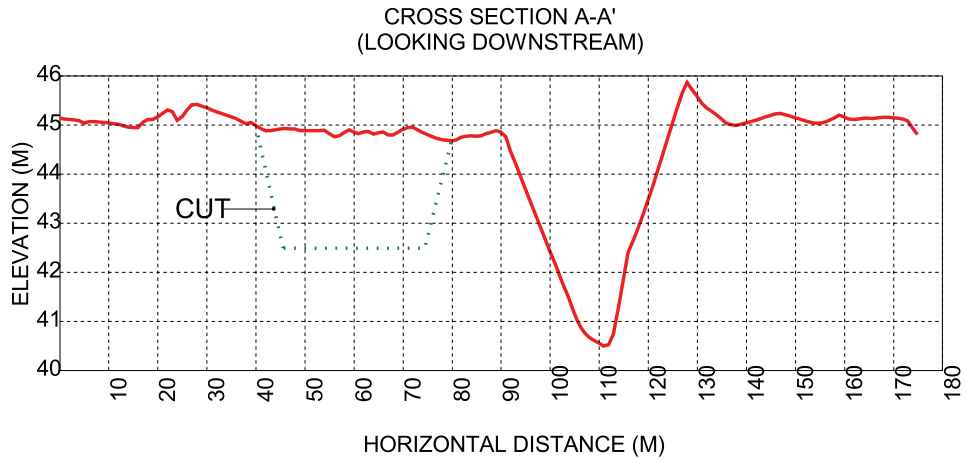
The depth of excavation (below existing floodplain ground surface) would be kept at 2 to 3 meters (7 to 10 feet), beginning about 2 meters (7 feet) above the existing creek bed, to minimize impacts to the existing riparian corridor and maintain summer low flows. The width of the in-channel terrace would vary from about 30 meters (100 feet) to about 50 meters (165 feet). Some 300 lineal meters (1,000 feet) of upper creek bank and bank top would be impacted by the channel-widening project. In some areas the toe of the existing bank would need to be stabilized by planted rock rip-rap.

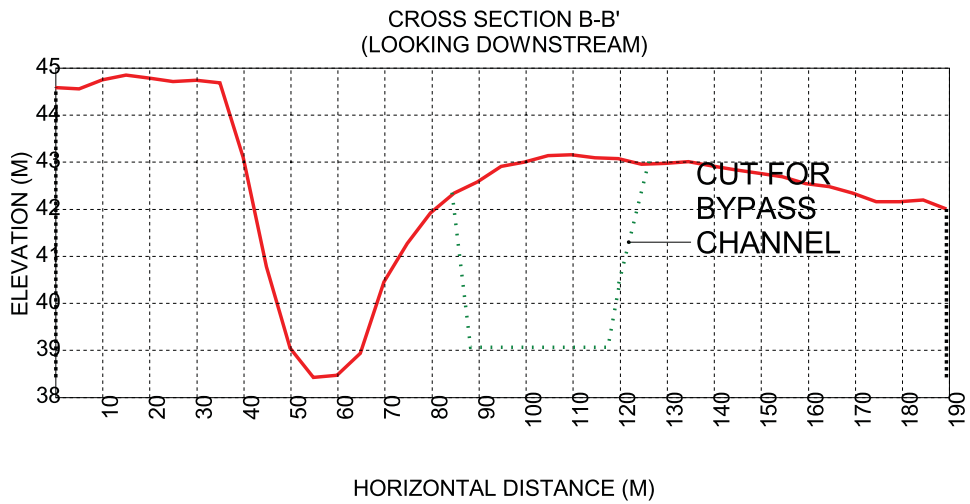
At certain locations, it will be necessary to construct a levee or berm along the west bank of the creek, especially near Elks Lane where flow currently leaves the stream channel. Any levees would have minimal impact on upstream water surface elevations since the channel capacity upstream of the levees would have increased due to the channel widening. The project will also require constructing a vertical retaining wall along about 120 meters (1400 feet) of creek channel in the area adjacent to the Mausoleum, as there is insufficient room for either a bypass or a terrace project in this area. Other project elements would include bank stabilization using planted rip-rap immediately downstream of Madonna road, and replacement of the Prado Road Bridge.

The advantage of channel widening over a bypass channel system is in lower construction costs, as less right-of-way would need to be acquired, and the amount of excavation and grading is reduced.

D.1.3 Floodplain Excavation in Mid-Higuera Area

This component of **Alternative 1 (Figure D-3)** would combine the channel maintenance and bank vegetation management along San Luis Obispo Creek between Marsh Street and Madonna Road similar to that described in the Preferred Project, including the excavation of an secondary overflow flood pathway (a large, shallow bypass channel) on the floodplain on the west side of the creek. However, the design would be modified in this alternative to focus channel excavation on the east side, from the Marsh Street Bridge to just downstream of Bianchi Lane Bridge, instead of through the Madonna Construction Company's yard. The 24 to 30 meter (80-100 feet) wide, bench or terrace would extend about 250 meters (825 feet) downstream of Marsh Street Bridge.





city of san luis obispo	**Elks Lane By-Pass** **SLO Creek Phase II** **Waterway Management Plan** QUESTA ENGINEERING CORPORATION	**Figure** **WMP 6-3**

D.2 Alternative 2- Low Cost/Low Impact Alternative

Alternative 2 represents a lower level of flood protection than the Preferred Project and the other project alternatives evaluated. Several of the individual project elements of this alternative are similar to the smaller components of the Preferred Project; but the more extensive channel modifications and floodplain bypass channel excavation components have been eliminated. For the most part, the projects associated with Alternative 2 would be restricted to specific channel constrictions or breakout points along San Luis Obispo and Stenner Creeks. Alternative 2 includes the following:

- Minor excavation and a revised vegetation management program along the reach of San Luis Obispo Creek between Marsh Street and Madonna Road.

- Replacing three bridges on Stenner Creek, as in the Preferred Project.

- Improving flood detention storage on San Luis Obispo Creek above Cuesta Park, as in the Preferred Project.

D.2.1 Channel Management Program

The proposed Channel Management Program of the Preferred Project would be retained in Alternative 2. However the amount of thinning and limbing work would be more conservative and scaled back substantially. Management would involve reducing the channel roughness of the creek banks for increased flow conveyance by very selectively thinning and limbing up the willows, and inter-planting taller growing, single-trunk native trees higher upon the creek banks. Sycamores and cottonwoods are favored. These would eventually shade out the shorter willows on the lower banks. In the short term, the lower branches on existing willows would be limbed and clumps of willows would be thinned down in volume and total number of stems during an annual maintenance visit. Any large gaps in the canopy would be inter-planted with tall, straight, tree forming species. Work would focus on willow management along the lower channel banks and planting trees and shrubs on the upper bank and bank top area.

The selective willow management program of the Preferred Project would remove most willow branches that are as low or lower than 6 feet, (maintenance crew could walk under the branches) except where over-hanging important pool areas. Under this alternative, willow branches would typically be limbed up only to 3 or 4 feet (maintenance crew would need to stoop to get under the tree branches).

Vegetation management would be completed in phases and take 5-7 years to become effective; however each year some important net reduction in channel flow resistance would be accomplished. Annual channel maintenance would be accomplished within the conditions of the overall Stream Maintenance and Management Program (SMMP).

A program of active channel vegetation maintenance will have some modest benefits in this stream reach, reducing flood water surface elevations for the 10-year flood

event by an estimated 0.1 to 0.2 meters, (0.3 to 0.6 foot), depending on location within the reach. However, the Design Flow Goal of a 20-year level of protection for this stream segment cannot be achieved with this alternative (and the other components).

D.2.2 Marsh Street Floodway Terrace

An additional component of Alternative 2 would entail excavation of a floodway terrace on the creek's east bank immediately downstream of Marsh Street bridge (at the McNamara Real Estate building property) as in the Preferred Project. Work on the east bank would involve removing 2-3 meters (7-10 feet) of soil in a zone extending eastward to Higuera Street 24 to30 meters wide (80 to 100 feet) and south past Bianchi Lane 250 meters (825 feet). In addition, some minor improvements to the channel upstream of Marsh Street Bridge would be included to reduce the effects of sediment and debris blockage of the bridge barrels. Implementation of this aspect of **Alternative 2** results in a predicted drop in water surface elevations of 0.28 m (0.9 ft) at the Marsh Street Bridge, but has little direct benefit elsewhere in the reach.

D.2.3 Replace Stenner Creek Bridges

As with the Preferred Alternative, the three undersized bridges on Stenner Creek (at Foothill, Murray, and Santa Rosa Streets) would be replaced as a component of Alternative 2.

Note: Geotechnical failure of the embankment for the Foothill Avenue Bridge in Winter 2001 has necessitated the replacement of that bridge for non-flood related reasons. Work began in April 2001.

D.2.4 Detention Storage on San Luis Obispo Creek above Cuesta Park

The detention storage flood control benefits of the undersized culvert at Cuesta Park would be enhanced as a component of this project, as in the Preferred Project.

D.3 Alternative 3 - Projects Not Considered Feasible and Not Evaluated Further

In preparing the flood management section of the WMP, a large number of flood control concepts were initially evaluated as a "long-list" of possible flood management alternatives. A number of these were considered earlier in the 1977 Nolte studies, by the Corps of Engineers, or by Shaff and Wheeler in the late 1980's. Upon further analysis by the project study team, these were not considered feasible, either from a technical, cost, or environmental and permitting difficulty perspective. These conceptual projects were eliminated in developing the "short-list" of project alternatives and were recommended by the Zone 9 Advisory Committee to be placed in the category of "Not Considered Feasible, and Not Evaluated Further". They are described here to provide a point of cost comparison to other alternatives and to document for future reference purposes that this alternative was considered in a preliminary fashion.

The projects, which were reviewed and determined to be infeasible, included:

Buried Bypass Culverts

- A buried bypass culvert around the downtown business district, running down Pacific Street or down Meadow Creek

Floodwalls

- Floodwalls along the east bank of San Luis Obispo Creek from Nipomo Street to Madonna
- A set of levees/floodwalls along both creek banks above Prado Road combined with property acquisition of floodplain areas on the stream side of the floodwalls
- A set of small levees/berms to prevent flow from spilling across Highway 101 between Madonna and Prado Roads
- Construction of a floodwall near Andrews Street/San Luis

Significant Channel Enlargement

- Significantly widening the channel of San Luis Obispo Creek between Marsh Street and Madonna Road to provide 50-year flood capacity

Flood Detention Basins

- Upper Stenner Creek
- Upper SLO Creek

D.3.1 Bypass Culverts

Buried Bypass Culvert, Downtown Business District. Downtown San Luis Obispo currently floods at between the 20- and 25- year recurrence interval because of low channel capacity and insufficient capacity of the large culvert (often termed the under city culvert) under Higuera Street between Osos and Chorro Streets. Replacing the under city culvert, increasing its capacity, or protecting the downtown area with levees or floodwalls are not technically feasible alternatives. Consequently, the only large-scale alternatives besides or in addition to detention for protecting downtown San Luis Obispo involves diverting a portion of the flow in excess of the under city culvert capacity into a bypass system.

Pacific Street Bypass Culvert. A buried concrete box culvert could be installed down Pacific Street, starting above Santa Rosa Street and re-entering the creek below the lower Marsh Street Bridge. The culvert would be approximately 3.7 m (12 ft) wide by 3.7 m (12 ft) deep for 100-year protection or 3.7 m (12 ft) wide by 2.4 m (8 ft) deep for 25-year protection. Since the excavation depth is not significantly different between a 25-year and 100-year project, the 100-year project would have the most advantageous cost-benefit ratio. For environmental reasons, a specialized inlet structure would need to be designed that prevented low flow and ordinary wet-season

runoff from entering the bypass without reducing the structure's capacity at high flow events. The design of such a structure would require a very detailed hydraulic model and possibly a physical modeling study to ensure adequate performance.

This project would entail major excavation and the relocation of all utilities within Pacific Street. The excavation would take up most of the street width and would preclude all use of the street during construction (estimated to take at least a year). Construction could be phased so that the entire street would not be torn up at once. Several large sewer collection, water, and gas distribution lines would be crossed by the project, as would several fiber optic cables. These utilities would need to be removed and replaced where they cross the culvert alignment.

Costs for this project are highly dependent on soil conditions and the shoring requirements of the excavation. Two different shoring techniques, sheet piles (least expensive) and soldier beams (most expensive), were used for cost estimating purposes to get a range within which the costs might occur. Utility relocation is included in the estimates.

Project engineers concluded (and the Zone 9 Advisory Committee concurred) that the buried culvert bypass project would not be feasible because of high costs (in excess of $20,000,000.00) relative to benefits, and the severe disruption that would occur to businesses located along Pacific Street.

Meadow Creek Bypass. An alternative solution to the Pacific Street Bypass for bypassing flow around downtown San Luis Obispo would be to install an open channel bypass down the current alignment of Meadow Creek, which flows from near the intersection of Islay and Toro Streets, through Meadow Park, and into San Luis Obispo Creek just below Madonna Road.

Currently, parts of this alignment are open channel, while other parts are contained within a buried storm water conduit. The City does not own an easement along this alignment; so acquiring property rights from the existing owners would be one of the more expensive aspects of the project. In addition, approximately 20 buildings would need to be acquired and moved or demolished for the project to proceed.

Because of the channel slope down the Meadow Creek alignment, flow velocities would require a concrete channel lining. To minimize the channel's footprint, a rectangular channel with dimensions of 20 feet wide by 10 feet deep would be the most efficient design.

Similar to the Pacific Street Bypass**,** a specialized inlet structure would need to be constructed at the upper end of the bypass, which would be near Johnson Avenue. The design of this structure would require detailed study.

While this project would extend further downstream than the Pacific Street Bypass, it would primarily benefit downtown San Luis Obispo. San Luis Obispo Creek would still experience relatively frequent flooding below the confluence with Stenner Creek even with a bypass in place.

Because of the high cost, (estimated to exceed $37,000,000.00) the lack of an existing easement, disruption of existing businesses, and major impacts to a creek, this alternative is not considered feasible.

D3.3 Floodwalls

Floodwalls along Mid-Higuera Reach. San Luis Obispo Creek between the Nipomo Street and Madonna Road bridges has less than a 10-year event channel capacity in many places. This is one of the first areas along San Luis Obispo Creek to experience flooding. Flooding occurs in the commercial area east of the creek and portions of Highway 101 near Madonna Road, when the channel overtops. Once the flood overtops Highway 101, water spills across the highway and flows on the west side of Highway 101 downstream to Prefumo Creek, where it returns to the main creek channel.

This alternative would contain flood flows between Highway 101 and a floodwall to be constructed along the creek's east bank. A floodwall would be installed along Highway 101 near Madonna Road to prevent flow from spilling across the highway.

Currently, when flow overtops the creek banks, Higuera Street becomes a relatively unobstructed pathway for floodwaters. If the conveyance represented by Higuera Street and the rest of the floodplain was removed and the flow was forced back into the creek by a floodwall, water surface elevations for a given storm would increase in the upstream direction above existing levels. To contain even a 25-year event behind floodwalls, the walls would need to be between 1.5 and 2 m (4.9 and 6.6 ft) high (somewhat less at upper end) and extend for the entire distance between Madonna Road and Nipomo Street. To contain a 50-year event, add 0.25 m (0.8 ft) to the height, and for a 100-year event, add 0.5 m (1.6 ft). Total wall height along San Luis Obispo Creek in the Mid-Higuera reach would than range to nearly 2.5 meters (8.2 feet).

The increase in upstream water surface elevation from Mid-Higuera floodwall construction would be approximately 1 m (3.3 ft) at the upper end of the wall, near Nipomo Street, for a 100-year flood, and 0.3 to 0.4 m (1 to 1.3 ft) for a 25-year event. This would represent a significant increase in flooding along Dana Street below Nipomo (just upstream of the confluence of Stenner and San Luis Obispo Creeks). Furthermore, preventing flow from spilling across Highway 101 near Madonna Road would force additional flow into San Luis Obispo Creek downstream of Madonna Road beyond what is currently experienced, increasing flood depths downstream. Finally, by placing a continuous barrier along the creek, local runoff from average-sized storms may not be able to find its way into the creek as easily as it currently does, potentially causing local flooding problems on the city side of the floodwalls. These impacts would require significant flood proofing mitigation, including purchasing and moving some buildings, elevating buildings, and wet flood proofing. The increases in water surface elevation are most pronounced at the 50- and 100- year events. They may make achieving anything higher than 25-year protection infeasible or unacceptable.

It is not possible to place a floodwall across a roadway. Instead, the roadway must be elevated to the required wall height. This would be a problem where the wall alignment crosses Marsh Street and the PG&E Bridge, just upstream of Marsh Street. The Marsh Street Bridge would need to be replaced with a higher structure. Work would also need to be done on the PG&E Bridge, though it probably would not require replacement. In any case, the Marsh Street Bridge will need to be elevated by the several meters. This would then require a significant road elevation project along Higuera Street to avoid exceeding maximum road slopes.

Currently, floods in this area rise slowly enough for people to escape the floodwaters. Holding back flood flows behind a floodwall or levee creates some risk of catastrophic failure. Failure of the wall would release a sudden flood wave that could cause loss of life. If the floodwalls are designed to provide protection only for relatively frequent storms (i.e. the 25-year event), it will be especially important to design them to perform safely when flow overtops the wall. Furthermore, if the floodwalls are designed to be overtopped on a relatively frequent basis, it will be important to consider how flow on the east (city) side of the walls would return to the stream channel. Because of these constraints, Mid-Higuera floodwalls are considered infeasible.

Floodwalls along Highway 101/Elevate Prado Road Onramp to Highway 101. Under existing conditions, flow in San Luis Obispo Creek spills across Highway 101 at several locations starting just above the 10-year event. Flow leaves San Luis Obispo Creek beginning just upstream of Madonna Road and continues to flow across Highway 101 to below Prado Road. Flow returns to the creek near the confluence with Prefumo Creek, near Los Osos Valley Road. Several 1 to1.5 m (3.3 to 4.9 ft) high floodwalls could be built at select locations on the east side of Highway 101 to prevent flow from crossing the highway. The onramp from Prado Road to Highway 101 is at one of the low points where flow leaves the creek. This interchange would need to be elevated to the same height as the floodwall.

This project would increase floodwater surface elevations along San Luis Obispo Creek by containing all of the flow in the main creek channel. The increases in flood depths would vary depending on location and storm size. An estimate for this flood depth increase is as much as 1 m (3.3 ft) at the 100-year event and 0.6 m (2 ft) at the 25-year event below Prado Road. Upstream of Madonna Road, the increase in flood depths would be approximately 5 cm (2 in) for a 100-year event and 3 cm (1 in) for a 25-year event.

Because some of these increases could occur in areas that currently do not experience flooding or areas that would become prone to flooding given these water surface elevation increases, other structural projects or local flood proofing would be required as mitigation to make this project feasible. On the east side of the creek, upstream of Prado Road, a floodwall would need to be constructed along the creek bank top to prevent increased water depths from spilling across Higuera Street. Without this floodwall, overflow could potentially cross a drainage divide and flood parts of the tank farm tributary of the East Branch of San Luis Obispo Creek. Another floodwall

on the east bank of the creek, below Prado Road, could be constructed to prevent flooding of the existing trailer park there.

The City corporation yard located south of Prado Road is a mobilization area for flood emergency response. Consequently, increased flood protection for this area is critical. This alternative would provide increased protection to the corporation yard during a 100-year storm, along with providing flood incident access from Highway 101. However, it could increase flooding depths in the adjacent Waste Water Treatment Plant (WWTP) and on the floodplains upstream of Prado Road. It would not be possible to protect the WWTP using floodwalls or levees without significant increases in upstream flooding depths. Consequently, this project assumes that only local flood proofing alternatives will be used to protect critical structures at the WWTP, such as raising berms and elevating some utilities and material storage areas. Floodwater would be allowed to flow through open areas of the plant.

Floodwalls/Levees near Prado Road. The hydraulic analysis shows that under existing conditions, flow from San Luis Obispo Creek leaves the main creek channel near Elks Lane and flows overland through the drive-in theater, across Prado Road, into the City's corporation yard and waste water treatment plant (WWTP), and then crosses Highway 101 or flows back into the main creek channel. This begins to occur at less than a 10-year recurrence interval storm. Below the WWTP and above the confluence with Prefumo Creek, the channel has approximately a 100-year capacity, except at the trailer park west of Higuera Street, which would begin to experience flooding at approximately a 25-year event (assuming all flow in San Luis Obispo Creek is kept on the east side of Highway 101).

The city corporation yard is a mobilization area for flood emergency response. Consequently, flood protection for this area is critical. This alternative involves protecting the corporation yard and WWTP by installing floodwalls/levees upstream of Prado road (or alternatively raising Prado Road itself), so that the flow that currently crosses Prado Road onto these sites is contained within the creek channel.

By preventing flow from freely crossing an area that currently provides flood flow conveyance, this alternative significantly raises the water surface elevation upstream of Prado Road. This rise in water surface is enough that the Prado Road Bridge would need to be replaced with a new structure several meters higher than the existing bridge. Levees would need to be installed between Highway 101 and the creek from Prado Road to above Elks Lane, and some elevation of parts of Elks Lane itself would be necessary. Because of increased flooding from floodwall construction and high mitigation costs, this alternative was not considered feasible.

Andrews/San Luis Drive Floodwall. During events larger than about a 25-year storm, hydraulic analysis shows that San Luis Obispo Creek overtops its banks along San Luis Drive above Andrews Street. Some of the lost flow re-enters at Andrews Street, and the rest flows down San Luis Drive to re-enter the creek near California Boulevard. Below Andrews Street, the creek has the capacity to convey a 100-year storm, including the flow that currently runs down San Luis Drive. This project

would utilize a low floodwall or earthen berm to prevent flow from leaving the main creek channel.

The floodwall would extend from the Andrews Street footbridge upstream for approximately 190 m (620 ft), through existing residents' rear yards. The wall would be between 0.6 and 1 m (2.0 and 3.3 ft) high for 100-year protection. For 50-year protection, placing soil berms at select low locations would likely be sufficient, although a detailed topographic survey would need to be performed to confirm this. Members of the project team met with residents of the Andrews Street neighborhood where the project would be built. Given the minor flooding that occurs here, and project aesthetic considerations, the neighborhood representatives did not support the project.

D.3.4 Significant Channel Enlargement

Channel Widening Between Marsh Street and Madonna Road. Flood protection for the Mid-Higuera Business district could be obtained by significantly widening the channel throughout the entire reach from Marsh Street downstream to below Madonna Road. For 100 -year protections, the channel would need to be widened about 25 to 30 meters (82 to 98 feet) or more. The bed of the widened channel would be about 2 m (6.6 ft) above the existing channel bed so that work within the existing channel would be minimized. At several locations within the Mid-Higuera Business District, existing structures and right-of-way would need to be purchased. The bridge at Madonna Road would need some modification, or an additional bypass bridge under Madonna Road would need to be constructed on what is currently Caltrans property. Downstream of the Caltrans yard, near the confluence with Meadow Creek, it is probably not possible to provide 100-year flooding protection because of the local constriction formed by the Mausoleum at the cemetery.
The project would entail the removal of most of the upper-bank and bank-top riparian vegetation within the project reach. Due to its high costs and relatively high environmental impact, and its relatively modest benefits, it was dropped from further consideration.

D.3.5 Flood Detention Basins

Upper Stenner Creek Detention Basin. Schaff and Wheeler's 1989 detention basin feasibility study (CITE) indicated that detention in the upper Stenner Creek area would require a large dam (about 50 or more feet high) due to the steep nature of the stream channel. No potential projects were found to have a positive cost-benefit ratio, and the environmental impacts of such a large dam on steel head fisheries would certainly make permitting such a project exceedingly difficult. Based on costs and adverse environmental impacts, a detention basin on upper Stenner Creek was not considered feasible.

Upper SLO Creek Detention Basin. Schaff and Wheeler (1989), and Nolte (1977) also investigated the feasibility of constructing a flood detention facility on upper SLO Creek above Cuesta Park and near Reservoir Canyon. As with the Stenner Creel

detention basin, it was concluded that the cost: benefit ratio was not favorable and adverse environmental impacts would make permitting of the project difficult.

D.4 Non-Structural Flood Control Alternatives

One of the main elements of the WMP is the development of new Policies and Programs for floodplain management. This is proposed to be implemented by adopting Special Floodplain Management Zones for the Mid-Higuera area, and the undeveloped lands along Prefumo and SLO Creeks downstream of Madonna Road. New Policies include prohibition of structures that block flood flow and return flow pathways in the Mid-Higuera area, and the proposed No Net Fill policy below Madonna Road. Demonstration of "No Adverse Impact" is required throughout the watershed, using the new Zone 9 computer hydrology/hydraulic models.

Alternatives to these proposed regulations include 1) **designation of a regulatory floodway** along portions of SLO Creek, 2) **prohibition of new development** or redevelopment on low recurrence interval (10-year or 25-year) floodplains, and 3) an expanded program of **flood prone property acquisition.**

D4.1 Floodway Regulation

Many communities with published FEMA floodplain maps have a special zone along a creek or river shown on the map that is termed a "floodway". This portion of the floodplain is where the highest flood velocities and greatest flood depths usually occur, and where buildings and their occupants are most at risk. This is also where development or encroachment can have the greatest effect on upstream or downstream flooding. Where a Floodway has been designated on a FEMA map, FEMA regulations adopted by communities usually prohibit any encroachment or obstructions within this regulated zone.

The FEMA maps covering the majority of the City of SLO do not show a regulatory floodway. A floodway is shown on the Flood Insurance Rate Map or FIRM for the portion of the creek that was enlarged in 1972 between downstream of Prado Road to LOVR. If the FIRM maps did delineate floodways within SLO, large portions of the community, especially in the Mid-Higuera area, would be included within it, making remodeling or redevelopment very difficult, if not impossible.

Although there are technical difficulties to precisely defining a regulatory floodway along many reaches of SLO creek, because of the degree of build-out, it is possible to do so using the new Zone 9 hydraulic model. As an alternative to the proposed floodplain management regulations included in the Preferred Plan, a regulatory floodway could be delineated along SLO Creek and its major tributaries that would preclude new encroachment into the floodway, and make rebuilding or remodeling difficult. This would require acceptance by FEMA of the hydrology and hydraulic studies completed for the project, the issuance of revised floodplain maps, and the adoption of a regulatory floodway ordinance by the City and County. This would be a major departure from current City Policy (included in the Preferred Plan) that permits building replacement in potential floodways along creeks, provided that building

elevation or flood proofing measures are incorporated into the design, the buildings occupy a similar footprint, and building shadowing and other techniques are used to maximize flood conveyance and minimize flow obstruction.

D.4.2 Floodplain Development and Redevelopment Prohibition

FEMA regulations currently allow development within a 100-year floodplain, provided that the bottom floor elevation of habitable buildings are (usually) one- to two-feet above the 100-year flood, and that any fill, including the buildings themselves, do not raise water surface elevations more than 1 foot.

Some communities have adopted regulations that do not allow development on vacant land within an active floodplain, or do not allow rebuilding of damaged buildings, or redevelopment within these flood prone areas. Usually a program of public purchase of lands that becomes for sale, or voluntary purchase of lands by a government entity is used to implement this policy and avoid a "taking" issue. Over time, as more lands are purchased, the lands often become parks or greenways along the creek or river. Acquisition by eminent domain is possible, but seldom used, and is typically not funded by agency grant programs.

The City of San Luis Obispo and SLO County could adopt such a Policy as a more stringent alternative means of floodplain regulation than is proposed in the Preferred Project. The regulations could cover only property downstream of Marsh Street, or Madonna Road, and/or only the 10-year floodplain in these areas. Considering the large amount of property within the 100-year floodplain, both developed and undeveloped, it would not be practical or economically feasible for the community to purchase all buildings or vacant lands that could be developed within the limits of the 100-year flood, or even the 25-year flood along SLO or Stenner Creeks.

In order to avoid condemning property and disrupting businesses, the City could have a program in place (and funding available) to purchase vacant property that is voluntarily put up for sale, or property that is substantially damaged (as defined by FEMA) and that should not be rebuilt or remodeled according to the new regulations. Generally such a program of voluntary purchase of buildings in the most active portions of the floodplain is only gradually successful over time, depending on property turnover, the repetitiveness of flooding, and flood damage.

D.4.3 Flood-prone Property Acquisition

An expanded version of the Preferred Project Non-structural flood management alternative could include a significantly larger program of acquisition of property in floodprone areas. This was evaluated as part of early planning for the Mid-Higuera Specific Plan. The expanded floodplain acquisition program alternative could include widespread acquisition of developed properties in the Mid-Higuera area, such as the mobile home park at Bianchi Lane, and the residential housing in the South Street – Brooke Street area of lower Mid-Higuera, as well as other properties on lower Stenner Creek. The program could also include vacant property acquisition in the Elks Lane area, as well as purchase of development rights along lower SLO Creek in

the unincorporated area below LOVR. Such an alternative would be very costly (tens of millions of dollars), and would not be consistent with the current City General Plan.

D.4.3 Other Regulatory Alternatives

As discussed in Section 5.0, the City of San Luis Obispo has established modest creek setbacks or buffer zones along all of its major creeks, but the County has no specific setback policy along SLO Creek in unincorporated areas. As a regulatory alternative the City could update its creek setback ordinance and create new Creek Development Standards that would apply to the kinds of land uses allowed within the setback zone. For instance different standards may apply to various creek reaches depending on the condition and biological value of the creek and its management needs. A larger setback might be needed along floodprone properties or areas with unstable banks, to allow for construction and repair of facilities. Different development standards may also be applied to urban infill lots than to larger parcels where the creek is in a more natural setting. Development standards might include design conditions on fencing, allowable parking structures, landscaping, , etc. The modification of creek setback and development standards could also be coordinated between the City and County in this Alternative, to include SLO Creek and other blue-lined or named creek tributaries.

Salinas River Watershed Management Action Plan

Central Coast Regional Water Quality Control Board
October 22, 1999

SALINAS RIVER WATERSHED MANAGEMENT ACTION PLAN

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SALINAS RIVER WATERSHED MANAGEMENT ACTION PLAN

Executive Summary

The purpose of the Salinas River Watershed Management Action Plan is to describe the Central Coast Regional Water Quality Control Board's (Regional Board) approach to watershed management for the Salinas River drainage area. The goal of watershed management is to more effectively protect and improve water resources by supporting development of local solutions to local problems. The Regional Board has broad authority to control both point source and nonpoint source pollution through implementing Federal and State laws and regulations. Historically, most effort has focused on controlling point source pollution through a system of federal and state permits and enforcement actions. However, many significant identified water quality impacts in the Salinas River watershed, such as erosion and sedimentation, nitrates in ground water and surface waters, and older, discontinued pesticides in sediments and animal tissues, are primarily associated with nonpoint pollution sources. Additionally, widespread pumping of ground water has contributed significantly to seawater intrusion into coastal aquifers. The result is another significant nonpoint source impact to both water quantity and quality.

Typically, nonpoint source pollution results when water moves across the landscape and picks up pollutants from roads, parking lots, lawns, agricultural fields, mining areas, construction sites and other land uses. These pollutants are carried into streams, rivers and ground water, where they affect water quality and the beneficial uses of the waters. Control of nonpoint source pollution requires the efforts of individuals, local governments and resource agencies. An effective watershed approach, emphasizing cooperative solutions, increased education, and development of partnerships, will improve control of nonpoint source pollution, while enabling the Regional Board to continue effective oversight and control of point source discharges.

The most significant elements of the Regional Board's watershed approach include devoting additional resources (staff time and grant funding) to watershed activities, increasing Regional Board presence in the watershed through developing partnerships with landowners, local governments, resource agencies, and other stakeholder groups. A closely related internal effort will be to integrate existing Regional Board programs and improve internal communication and coordination to increase efficiency and provide better service. Through the combined efforts of many individuals, groups, and agencies with responsibilities and interests in the watershed, the Regional Board believes significant gains in water resource protection will be realized.

Description of the Salinas River Watershed

The watershed of the Salinas River and its tributaries covers approximately 4,600 square miles (nearly 3 million acres) and lies within San Luis Obispo and Monterey Counties (Figure 1). The Salinas River, which originates in San Luis Obispo County, flows northwestward into Monterey County, through the entire length of the Salinas Valley and empties into Monterey Bay. The watershed's main tributaries are the Arroyo Seco, Nacimiento, San Antonio, and Estrella Rivers. The two primary ground water basins within the Salinas watershed are the Salinas Valley Ground Water Basin and the Paso Robles Ground Water Basin (Figures 2 and 3).

The Salinas River drains a large watershed with a number of distinct tributaries; however, geographic, political, land use and ground water divisions facilitate discussion of the Salinas River watershed in terms of an upper and a lower watershed. The upper watershed begins at the headwaters of the Salinas River in the La Panza Range southeast of Santa Margarita Lake in San Luis Obispo County and flows to the narrows area near Bradley, just inside Monterey County. The upper watershed includes drainages of the Estrella, Nacimiento and San Antonio Rivers. The upper watershed overlies the Paso Robles Ground Water Basin and lies mainly in San Luis Obispo County. The lower watershed extends from the Bradley narrows area to Monterey Bay and includes the drainage of the Arroyo Seco River. The lower Salinas River watershed overlies the Salinas Ground Water Basin and is entirely within Monterey County.

Agriculture is the primary land use within the entire Salinas River watershed. Grazing and pasture lands and dryland farming have historically been the dominant land use in the upper watershed, but large areas in southern Monterey County and northern San Luis Obispo County are being converted to vineyards. Irrigated cropland is predominant in the lower watershed, primarily row crops such as lettuce, celery, broccoli and cauliflower on the valley floor, with grazing and vineyards on the upland areas. The lower watershed is one of the most productive agricultural areas in the world, with a gross annual value of nearly $2 billion. The rapidly expanding wine-producing region in the upper watershed around Paso Robles is also becoming a highly productive agricultural area.

Urban development occurs primarily in a corridor along the Salinas River. The largest city, Salinas, has more than 100,000 people and is developing rapidly. Urban development in the upper watershed is occurring in the small cities of Santa Margarita, Atascadero, Templeton and Paso Robles, which are also growing rapidly.

In addition to agriculture and urban development, other land uses in the Salinas River watershed include two military facilities (Fort Hunter Liggett and Camp Roberts), exploitation of mineral and oil reserves in the San Ardo area and a few other locations throughout the watershed, and some public land and open space. The watershed has three dams, one on the upper Salinas River south of Santa Margarita, one on the Nacimiento River and one on the San Antonio River.

Assessment of Water Resource Issues

Staff completed a preliminary assessment of water resource issues in October 1997. Available monitoring data, although not exhaustive, indicate water quality impacts are widespread. Identified impacts include seawater intrusion in the coastal areas near Castroville and Salinas, nitrates in ground water and surface water, pesticides in sediment and animal tissues, mercury in Lake Nacimiento and its tributaries, and erosion and sedimentation. The Paso Robles Ground Water Basin includes an area where highly mineralized geothermal wells contribute to ground water pollution. Pollutants such as pesticides, nutrients and sediment are often associated with agricultural activities, although agriculture is not the only source. Other potential pollutant sources in the watershed are urban storm water runoff, mines, oil fields, geothermal areas, roads and highways, and point source discharges.

The Salinas River and several tributaries have been listed by the Regional Board on the Clean Water Act's 303(d) list of impaired water bodies. Impaired water bodies are those waters which do not fully support all of their designated beneficial uses. All waterbodies on the 303(d) list are scheduled for development and implementation of Total Maximum Daily Loads (TMDLs) within the next several years. Developing and implementing a TMDL is a process which includes identification of sources and allocation of load reductions needed to restore beneficial uses. TMDLs are further described below and in Appendix A. along with a table of currently scheduled TMDLs (Table One). The Regional Board will work closely with landowners and other stakeholders in the watershed to ensure that the watershed approach is coordinated with all TMDL efforts.

In January 1999, the Regional Board's Regional Monitoring Program began monitoring the Salinas River and some of its tributaries to provide current ambient water quality data. In addition, the Regional Monitoring Program has gathered water quality data from numerous agencies and is in the process of creating a complete bibliography of references and a database of water quality data for the Salinas River. The Regional Monitoring Program, along with landowner and citizen monitoring, and TMDL development, will enable the Regional Board to further refine its assessment of water resource issues over the next two years.

Regional Board Responsibilities and Regulatory Authority

The Regional Water Quality Control Boards have responsibility for protecting the quality of the waters of the State of California. Waters of the State are defined as any surface and ground waters, including saline waters, within the boundaries of the State. Regional Boards protect water quality by implementing a number of Federal and State laws and regulations, including the Federal Clean Water Act (CWA), the State Porter-Cologne Water Quality Control Act, and the Coastal Zone Act Reauthorization Amendments (CZARA).

The State Water Resources Control Board and the nine Regional Boards were established by the Porter-Cologne Water Quality Control Act nearly 30 years ago. Under Porter-Cologne (promulgated as Division 7 of the California Water Code), Regional Boards are required to develop water quality control plans (Basin Plans), which describe the Regional Board's approach

for protection of water quality. Basin Plans identify beneficial uses for all of the region's waterbodies, including rivers, streams, bays, estuaries, wetlands and ground water basins, and establish standards for water quality (water quality objectives) which ensure beneficial uses are protected. Objectives can be numeric (e.g. the concentration of nitrate in drinking water shall not exceed 45 milligrams per liter) or narrative (e.g. suspended sediment shall not adversely impact beneficial uses). The Central Coast Regional Board's Basin Plan lists twenty-two beneficial uses for the waterbodies of the region, including drinking water supply, agricultural water supply, recreation, aquatic habitat, fish migration, and fish spawning. Twenty are applicable to the Salinas River watershed.

The Regional Boards have been given very broad authority to protect water quality under Porter-Cologne, regardless of the source of pollution. The historical focus of the Regional Boards has been on controlling point source pollution, primarily through a system of state and federal permits. Several recent events have put much greater emphasis on nonpoint source pollution and legal requirements related to controlling it. In addition to water quality assessments which indicate nonpoint source impacts, these events include listings of steelhead trout and Coho salmon under the Endangered Species Act along much of the California coast, lawsuits against the Federal Environmental Protection Agency and the State of California for failure to implement provisions of the Clean Water Act related to impaired waterbodies (Total Maximum Daily Loads), and the required statewide upgrade of the Nonpoint Source Program to satisfy requirements of the CZARA.

Development and implementation of Total Maximum Daily Loads (TMDLs) and implementation of the Nonpoint Source Program will be key components of the Regional Board's watershed approach in the future. Waterbodies in the Region which are identified as impaired through water quality assessments are targeted for TMDL development. Implementation of TMDLs in the Salinas River Watershed will focus on greater control of nonpoint source pollution. The Regional Board will work with landowners, local watershed groups, local government and other partners in the development and implementation of TMDLs.

A list and description of Regional Board authority and programs applicable to the Salinas River watershed are included in Appendix A.

California's Watershed Management Initiative

In 1995 the State Water Resources Control Board and Regional Boards conducted an assessment of their effectiveness. The assessment resulted in the Board's Strategic Plan, which recommended, among other things, that Regional Boards begin to look at water quality issues on a larger, more comprehensive watershed scale. As a result, the State adopted the Watershed Management Initiative. Based on establishment of the Watershed Management Initiative, the Regional Board began active development of a more systematic approach to manage nonpoint sources of pollution, even in light of limited staff resources. The framework for determining the need to develop and implement a control strategy for a given nonpoint source pollution problem considers four factors: 1) the magnitude of the problem (through assessment), 2) the presence of

existing institutional and community action, acceptability, and/or willingness to partner in addressing problems (stakeholder involvement), 3) the presence of existing government agencies as potential responsible parties for controlling the problem, and 4) opportunities to coordinate with existing internal staff efforts (e.g., outreach, point source control strategies, monitoring. It became apparent that many regulatory and non-regulatory activities were already underway throughout the Region to address both point and nonpoint sources of pollution.

The Central Coast Regional Board designated the Salinas River watershed as one of its priority watersheds in 1996. A team of staff was formed to manage the traditional programmatic regulatory work in the watershed, including permit writing, enforcement, water quality certifications, and regulation of landfills, underground tanks, and cleanups. In addition, the team's charge was to develop a watershed management plan. The team wrote a two-year, task-oriented strategy (Strategy) to develop a Watershed Management Action Plan. Initial tasks included development of a comprehensive stakeholder list, an inventory describing the agencies, organizations, and groups active in the watershed along with their authority, interests, and current activities, as well as a preliminary assessment of water resource issues within the watershed. In addition to generating the Watershed Management Action Plan, the Strategy's final tasks included an evaluation of water resource issues.

For the past two years, staff has been working on completing the tasks of the Strategy document. To accomplish this effort, staff has taken the approach of participating in water quality and watershed based efforts that were already underway in the watershed with such agencies as Natural Resources Conservation Service, Resource Conservation Districts, University of California Cooperative Extension, the Water Quality Protection Program for the Monterey Bay National Marine Sanctuary, and Monterey County Water Resources Agency. The rationale for such an approach was to capitalize on existing efforts, develop relationships within the watershed, look for opportunities to link on-going efforts so as to preclude duplication of effort, and assess the need for further outreach by the Regional Board. Staff determined that with a more centralized approach to handling of Clean Water Act Section 401 Water Quality Certifications and California Environmental Quality Act (CEQA) review and comment, the Regional Board would be able to obtain a more complete picture of ongoing watershed activities.

Watershed management focuses on development of cooperative relationships within a watershed, with the intent of developing common goals. The challenge for a regulatory agency such as the Regional Board is to balance the time necessary to develop cooperative efforts to improve water quality with legal mandates which the Regional Board must meet. Nonpoint source pollution can only be controlled through widespread implementation of management practices by all land uses. The challenge over the next few years will be to develop better means of tracking implementation of management practices necessary to control nonpoint source pollution and to put into place monitoring and reporting procedures that can assure the Regional Board that regulatory requirements are being met, while preserving the flexibility and self-determination desired by landowners and others.

The watershed management action plan considers ways of incorporating existing regulatory responsibilities of the Regional Board into watershed management, and how to coordinate

Regional Board responsibilities with those of other organizations. The size of the Salinas River watershed and the level and types of activities may make it unique, but many of the agencies, organizations and programs will be the same in other watersheds.

Partners/Watershed Efforts in the Salinas River Watershed

A key component of an effective watershed management approach is developing partnerships. No one agency or individual can accomplish all that needs to be done to protect water resources in a watershed. Collaborative efforts have the most chance of enduring and producing long-term benefits. One of the initial efforts by staff was to compile a list of stakeholders in the watershed and an inventory of the many on-going efforts conducted by other organizations. The Regional Board is currently working with many of these groups whose efforts are focused on resource protection and reduction of nonpoint source pollution. Regional Board involvement includes attendance at meetings, participation on technical advisory committees, presentations at meetings and short-courses, and assistance with funding.

Appendix B contains a summary of several current efforts in the Salinas River watershed with which the Regional Board has involvement. This summary is not meant to be exhaustive, however, because new efforts are continually being initiated throughout the watershed.

Regional Board Watershed Management Activities in the Salinas River Watershed

The principal elements of the Regional Board's watershed approach are devoting additional resources (staff time and grant funding) to watershed activities and increasing Regional Board presence in the watershed through developing partnerships with local governments, resource agencies, citizen groups and landowners. A closely related internal effort will be to integrate existing Regional Board programs and improve internal communication and coordination to increase efficiency and provide better service to both point source dischargers and other constituents in the watershed.

Specifically, the following activities will receive priority in the coming two years:

1. Working with various current and new partners throughout the watershed to encourage development of cooperative projects that support a comprehensive watershed approach, using funding such as Clean Water Act planning and implementation funds;

2. Addressing existing program work such as permitting and inspections through adequate staffing and coordination among staff;

3. Encouraging and supporting expanded offerings and participation in the Ranch Water Quality Planning short courses as well as participating in the development and implementation of similar courses for vineyards and row crops;

4. Working with the State Farm Bureau Federation and the Six County Coalition of Farm Bureaus to implement the Farm Bureau's Nonpoint Source Initiative pilot projects as described in the Monterey Bay National Marine Sanctuary's Plan for Agricultural and Rural Lands;

5. Working as a member of the Sanctuary's Water Quality Protection Program to implement elements of existing plans, such as cross training for agency staff, streamlined permitting for water quality protection projects, and improved coordination between agencies;

6. Encouraging resource planning and the development of resource management plans, such as those promoted by Water Quality Planning short courses and the Central Coast Vineyard Team's positive point system;

7. Evaluating impacts from wine processing facilities and developing recommendations for consistent management;

8. Expanding outreach to cities, counties and urbanized areas regarding the Storm Water Program and upcoming requirements for municipal, industrial and construction storm water permits in conjunction with the Sanctuary's Model Urban Runoff Program;

9. Continuing participation in the Irrigated Agriculture Roundtable, which is sharing information among Regional Boards and working to better define the tiers and options of the Nonpoint Source Program as it relates to irrigated agriculture;

10. Continuing regular (monthly) briefing meetings for staff to share information, coordinate activities, strategize efforts and explore opportunities for streamlining and improved coordination of Regional Board programs (Appendix C lists possible points of discussion);

11. Intensifying efforts with Monterey County Water Resources Agency, other local agencies and partners to implement the action plans for managing nitrate pollution and seawater intrusion in the lower Salinas Valley Ground Water Basin;

12. Improving our understanding of, and initiating action planning for, the potential impacts from highly mineralized geothermal wells located in the Paso Robles Ground Water Basin and making recommendations to modify ground water objectives for the Paso Robles Ground Water Basin as appropriate;

13. Initiating TMDL outreach efforts for the Salinas River and tributaries for sediments, nutrients, pesticides and mercury;

14. Assisting with the development of the Regional Board's Regional Monitoring Program and encouraging widespread use of the data for watershed planning and TMDL development and implementation;

15. Encouraging more comprehensive, watershed-based approaches to issues of flood control, in-stream sand and gravel mining, and land use planning decisions; and

16. Supporting efforts to develop watershed-based approaches through development of coordinated funding efforts.

Milestones

To evaluate the effectiveness of the above activities and better protect water quality, the Regional Board will develop a tracking system for management practice implementation and establish a baseline inventory of currently implemented management practices for each major land use category (row crops, vineyards, rangeland, urban). The baseline information will be used to develop interim targets and timelines for widespread implementation of management practices to support both improved control of nonpoint source pollution and implementation of TMDLs.

The Regional Board will work to develop a prototype of management plans for watersheds or subwatersheds which will allow for flexibility and adequate time for implementation, incorporate monitoring, and satisfy accountability and regulatory reporting requirements through the Nonpoint Source Program.

In addition to the above nonpoint source efforts, the Regional Board will meet all workplan commitments for State Water Resources Control Board programs, including National Pollutant Discharge Elimination System permits and Waste Discharge Requirements.

Reassessment and Future Actions

By the end of fiscal year 2000-2001 (June 30, 2001), the activities described above will have been underway for two years, and milestones developed, giving the Regional Board a better understanding of the level and effectiveness of management practice implementation throughout the watershed. Several more Ranch Water Quality Planning short courses should have been offered as well as pilot courses for the Farm Water Quality Planning short courses, resulting in development and implementation of a number of farm and ranch plans. The Six County Farm Bureau Coalition's pilot project in Salinas should be underway and a protocol for providing information developed. In addition, a sediment TMDL will be developed and implementation begun. Staff will have been meeting on a monthly basis for two years and will have had time to explore the suggestions for improved coordination and streamlining of regulatory activities described in Appendix C.

Following the two year effort, the Regional Board can assess the information available and determine how future effort may be directed. Regional Board staff will evaluate the success of voluntary/self-determined compliance with the Nonpoint Source Management Plan (Tier I) by looking at levels of response, success of the Farm Bureau pilot projects, response to surveys and development of management plans, attendance and participation at short courses, numbers of

plans developed and implemented and whether information on management practices is adequate to assess progress. Regional Board will also assess effectiveness of efforts to improve erosion control, success of internal coordination efforts, and information provided by the Regional Board's Regional Monitoring Program.

Based on the above assessments, the Regional Board will consider whether progress toward improving water resources is adequate or if modification of the watershed management strategy is necessary. If voluntary/self-determined efforts to control nonpoint source pollution appear to be moving forward and participation is increasing, there may be no need for increased regulatory involvement. However, if two years of sustained effort by the Regional Board and its watershed partners does not appear to be increasing implementation of management measures, then other regulatory options may need to be considered. The Regional Board recognizes that improvements to water quality through control of nonpoint source pollution take time and direct water quality improvements cannot always be measured immediately. Therefore, other indicators will be looked at, as described above. The Regional Board has a legal responsibility to protect the waters of the State of California and must be able to show measurable progress toward water quality improvement. Staff will complete the assessments and intends to make further recommendations to the Board by December 2001.

Figure 1
Salinas River and Major Tributaries

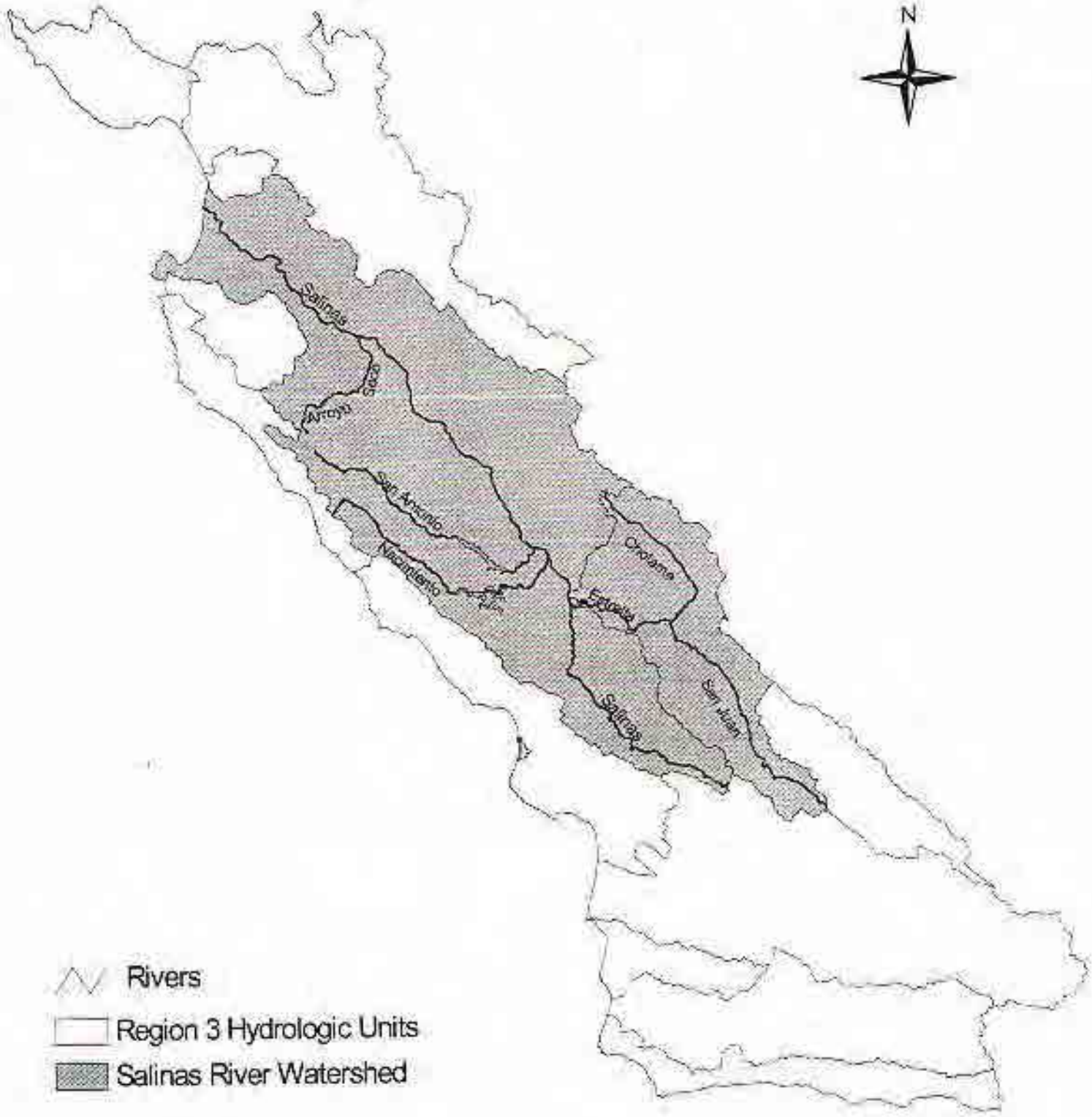
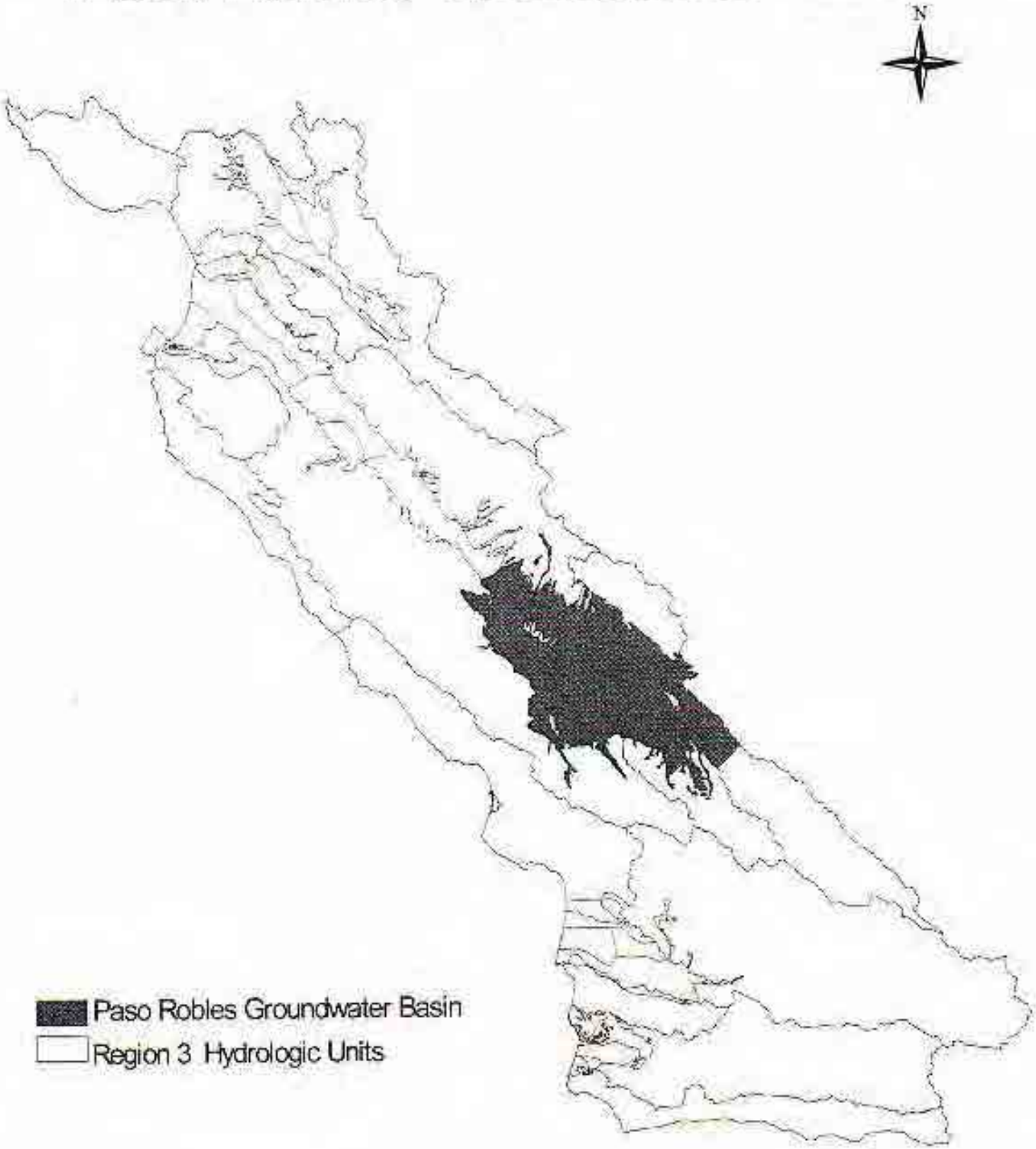


Figure 2
Salinas Valley Groundwater Basins

Figure 3
Paso Robles Groundwater Basin



Appendix A
List of Regional Board Regulatory Authority and Programs

Permitting of Point Source Discharges through Waste Discharge Requirements and Federal NPDES Permits

With the adoption of the Porter-Cologne Water Quality Control Act in 1969, the State of California set up a system for control of discharges to land through issuance of orders called Waste Discharge Requirements (WDRs), which are issued to many facilities, including industrial facilities, landfills, and many wastewater treatment plants. The National Pollutant Discharge Elimination System (NPDES) was established by the Federal Clean Water Act (CWA) in 1972 and gave authorized states such as California authority to issue federal permits for pollutant discharges to surface water. Both WDRs and NPDES permits require that the quality of discharges comply with certain established standards, and require monitoring and reporting.

Nonpoint Source Management Plan and Nonpoint Source Program/Coastal Zone Act Reauthorization Amendments (CZARA)

In 1987 the CWA was amended to include Section 319, requiring states to address nonpoint sources of pollution through development of management plans for controlling nonpoint sources. In 1988, California adopted the Nonpoint Source Management Plan, outlining a three-tiered approach of increasing regulatory involvement for controlling nonpoint source pollution. The three-tiers consist of: 1) voluntary/self-determined implementation of management measures to control nonpoint source pollution (Tier I), 2) regulatory-encouraged implementation of management measures, primarily through waiving Waste Discharge Requirements (Tier II), and 3) issuance of Waste Discharge Requirements (Tier III) in which management measure implementation is required.

California has chosen to upgrade and expand its Nonpoint Source Program to satisfy requirements of the U.S. Environmental Protection Agency (USEPA) and the National Oceanic and Atmospheric Administration (NOAA), which share responsibility for approval of state coastal programs. This effort resulted from Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA), which requires States to develop and implement management measures for nonpoint source pollution to restore and protect coastal waters. The State Water Resources Control Board (SWRCB), the nine Regional Water Quality Control Boards, and the California Coastal Commission (CCC) have shared responsibility for implementation of the approved program. California is currently in the process of completing its revised program and submitting it to the SWRCB and CCC for adoption, subject to final approval by USEPA and NOAA. The upgraded program will require greater accountability from the State and Regional Boards to show that management measures are being implemented to control nonpoint source pollution from a variety of land use activities, including urban areas, agriculture, forestry, hydromodification and marinas.

Storm Water Program

In 1987, Congress enacted a two-phased program under Section 402(p) of the Clean Water Act that requires National Pollutant Discharge Elimination System (NPDES) Permits for storm water discharges. As with the NPDES program for point source discharges, the NPDES Storm Water Program is administered through the State and Regional Boards. Since 1990, "Phase I" regulations have required NPDES permits for storm water discharges for (1) municipal separate storm sewer systems serving populations greater than 100,000, (2) specific industrial activities, and (3) construction activities disturbing five or more acres of land. "Phase II" regulations are scheduled for adoption in 1999. These regulations will expand the existing NPDES Storm Water Program to include smaller municipalities and construction sites that disturb between one and five acres. Phase II permits are anticipated to be required by May 31, 2002.

Clean Water Act Section 401 Water Quality Certifications

Section 401 of the CWA gives the Regional Board authority to review federal permitting actions related to work in waters of the State. Any U.S. Army Corps of Engineers permit issued pursuant to Section 404 of the CWA requires water quality review by the Regional Board to be valid. Section 401 Water Quality Certification gives the Regional Board the ability to protect wetlands through reviewing and conditioning any Section 404 permit.

Total Maximum Daily Loads (TMDLs)

Section 303(d) of the CWA requires States to periodically assess the quality of their waters and identify waterbodies that are not fully supporting their designated beneficial uses. Waterbodies, such as rivers, streams, lakes, bays and estuaries, that do not or are not expected to meet water quality standards after applying existing required controls, such as minimum sewage treatment technology, are targeted for TMDL development. TMDLs are derived by a process of assessing water quality problems, identifying sources, and determining load reductions or control actions needed to restore and protect beneficial uses of impaired waterbodies. The Salinas River and some of its tributaries have been listed on the CWA 303(d) list by the Regional Board for a number of pollutants. A TMDL for mercury is scheduled to be developed for Las Tablas Creek and Nacimiento Reservoir by June 2000. The first scheduled Salinas River TMDL (for siltation and sedimentation) is due to be completed by June 2001. Several others are scheduled for development over the next five years. TMDL development and implementation will be a phased process that will involve landowners and other throughout the watershed in widespread implementation of management measures that will reduce nonpoint source pollution.

Appendix B
List of Partners and Watershed Efforts in the Salinas River Watershed

Monterey Bay National Marine Sanctuary: Water Quality Protection Plans for Agriculture and Rural Roads

The Water Quality Protection Program (WQPP) of Monterey Bay National Marine Sanctuary is a cooperative effort by many groups and agencies in the watersheds contiguous to the Sanctuary, including federal and state agencies, cities, counties, and representatives from industry. The WQPP has developed water quality plans for urban areas and marinas, and has been working with the State Farm Bureau Federation and Farm Bureaus in counties contiguous to the Sanctuary to develop and implement an action plan for agriculture. Regional Board staff has been extensively involved in developing the plans and will be working closely with cities, counties, local entities, the Farm Bureaus and WQPP to implement the plan.

California State Farm Bureau Federation/Six County Farm Bureau Coalition: Nonpoint Source Initiative Pilot Projects

The California State Farm Bureau Federation is developing a proactive, watershed-based approach to addressing nonpoint source pollution from agricultural activities. In the Monterey area, six local county Farm Bureaus have developed an agreement to work together to pilot the SFBF's Nonpoint Source Initiative through organizing watershed groups of landowners to implement management practices. Regional Board staff will be working with the Farm Bureaus to develop plans and monitoring and reporting protocols that will serve to satisfy TMDL and Nonpoint Source/CZARA requirements.

Monterey County Resource Conservation District (RCD): Eastside Erosion Control Project

The Monterey County RCD is implementing a CWA 319 project to control erosion and offsite migration of nutrients. This project is being considered as a location for the Farm Bureau pilot projects described above.

Monterey County Water Resources Agency: Salinas Valley Water Project/Nitrate Technical Advisory Committee/Castroville Seawater Intrusion Project

As part of the Salinas Valley Water Project, a Nitrate Technical Advisory Committee (NTAC) was convened in 1997 by Monterey County Water Resources Agency (MCWRA) to develop a Nitrate Management Plan to reduce the widespread contamination of ground water by nitrates. Staff attends NTAC meetings, manages the CWA 319(h) project by MCWRA to implement nitrate management practices and develop a survey of grower nutrient management practices, and is working to link the nitrate management effort with other agricultural nonpoint source outreach efforts such as the Monterey County RCD's project for erosion control and nutrient management. The Castroville Seawater Intrusion Project delivers recycled water to growers in the Castroville area to reduce pumping that is causing seawater intrusion.

Natural Resource Conservation Service: EQIP Local Work Groups

The Natural Resource Conservation Service (NRCS) is implementing U.S. Department of Agriculture's Environmental Quality Incentives Program (EQIP), which provides cost-share

funding to ranchers and farmers who implement practices which protect resources. NRCS convenes Local Work Groups, composed of landowners and staff from NRCS, University of California Cooperative Extension (UCCE), Resource Conservation Districts, Regional Boards and other interested parties. Local Work Groups identify priority areas and criteria for eligibility for cost share funds. EQIP also provides funding for educational projects and areas of special concern, including steelhead and salmon restoration projects. EQIP funds are supporting Ranch Water Quality Planning short courses and may be used to offer similar courses for irrigated agriculture in the future.

University of California Cooperative Extension: Ranch Water Quality Planning Short Courses The Rangeland Water Quality Management Plan (RWQMP) was developed with industry support and adopted by the State Water Resources Control Board in 1995. The goal of the RWQMP is to encourage voluntary efforts by ranchers to reduce nonpoint source pollution and develop resource management plans for their ranches that address water quality issues. Ranch Water Quality Planning Short Courses are offered by throughout California by University of California Cooperative Extension (UCCE) with participation by NRCS and Regional Boards. In the past year three short courses have been offered in the Salinas River watershed and more are proposed for the coming year.

University of California Cooperative Extension: Water Quality Planning Short Courses for Irrigated Agriculture
Currently, UCCE staff is developing and offering a short course for vineyards which is modeled after the Ranch Water Quality short courses. UCCE is interested in expanding the format to include row crops and has received grant funding from USDA to begin developing course materials. Regional Board staff will continue to assist with the development and implementation of the short courses and has given them priority for CWA Section 319(h) funding.

Upper Salinas Las Tablas Resource Conservation District: Erosion Control Training
The Upper Salinas and Las Tablas RCD has developed an educational brochure targeted at home builders to increase their awareness of erosion control measures. Staff has begun coordinating with the RCD to increase distribution and use of the brochure and is working with the RCD and with San Luis Obispo County to develop an erosion control training class designed specifically for county planners, inspectors and engineers.

County of San Luis Obispo: Master Water Plan Update
San Luis Obispo County is beginning a large public outreach effort as part of its revision of the current master water plan. Staff has been participating in meetings of the Water Resources Advisory Committee and the North County Water Task Force. The County is proposing to develop public participation in each water planning area, one of which encompasses most of the Upper watershed. Staff will continue to participate in meetings as appropriate as an avenue to increase public outreach in the upper watershed. In addition, the County is proposing to fund a study of the Paso Robles Ground Water Basin. Staff has listed a study of the basin in the current list of priorities for CWA Section 205(j) funds.

Atascadero Ground Water Guardian/Upper Salinas Watershed Coalition: Citizen Monitoring/Watershed Assessment

A local group has convened in Atascadero that is focusing on watershed protection through participation in the national Ground Water Guardian program and development of a citizen monitoring program. Their interests include ground water protection, urban stream restoration and watershed assessment.

American Watersheds: Watershed Assessment/Fluvial Geomorphological Analysis

A conservation partner with the Upper Salinas-Las Tablas Resource Conservation District, the group is focusing efforts in the Atascadero area and will eventually expand to other parts of the Upper Salinas and tributaries.

Sustainable Conservation/Natural Resources Conservation Service: Permit Streamlining Projects

Landowners are sometimes reluctant to initiate projects near streams which might have beneficial effects on water quality because of cost and the number of agencies and permits involved. The Natural Resources Conservation Service (NRCS) and Monterey County Resource Conservation District, as part of their erosion control work with landowners in Elkhorn Slough, in partnership with Sustainable Conservation, worked with agencies to develop a streamlined process for a specific list of management practices. Landowners now go directly to NRCS and are able to implement beneficial practices without contacting any other agencies. This has encouraged a large number of projects which might not otherwise have been implemented. Staff developed the CWA Section 401 Water Quality Certification for this project, and is managing a similar CWA 319(h) project for the Salinas River watershed. A similar approach is being considered for the upper watershed.

Central Coast Vineyard Team: Positive Point System

The Central Coast Vineyard Team is a group of winegrape growers that focuses education and outreach efforts on sustainable resource management in vineyards. The Team has developed a positive point system that allows growers to assess soil, water, nutrient and pest management practices. The Team also offers tailgate meetings for growers. Over the past three years more than 10,000 acres of vineyards in the Central Coast area have been evaluated using the positive point system.

Watershed Institute: Wetland Restoration Activities

The Watershed Institute has a number of wetland restoration projects underway in the Salinas River watershed. The Institute works with landowners and educational groups to increase awareness of the benefits of wetlands.

Ventana Wilderness Alliance: Citizen Monitoring

The Ventana Wilderness Alliance is a group which is conducting a citizen monitoring effort on the Arroyo Seco River to protect steelhead habitat.

Appendix C
List of Suggestions for Internal Coordination and Streamlining

- Combine review of WDR monitoring and reporting with storm water monitoring and reporting; investigate the feasibility of integrating into WDRs as permits are renewed.

- Develop and present workshops on upcoming NPDES Phase II Storm Water regulations, using the Model Urban-Runoff Guide and Region 2's construction erosion control materials as a starting point; workshops could be held in Monterey and San Luis Obispo counties, targeting municipalities, counties, developers and contractors.

- Increase coordination with municipalities and counties to improve oversight, increase our knowledge of potential problems, and increase awareness of erosion control among inspectors, contractors and developers; combine inspections (WDRs, NPDES and storm water).

- Develop and present workshop on road maintenance and erosion control techniques and issues for improved water quality protection.

- Work with counties to develop a streamlined process for submitting applications and coordinating site visits.

- Work with RCDs to increase outreach to homeowners regarding erosion control and work in streams; find venues for distribution of educational materials developed by RCDs.

- Combine workshops for road erosion control and construction with NPDES Phase II Storm Water erosion control (invite county staff from planning, public works and any other department, cover both topics).

- Coordinate oversight of Salinas River channel work with California Department of Fish and Game and MCWRA.

- Make presentations at annual training held by Salinas River Channel Coalition and MCWRA to increase compliance with CWA Section 404/401 Regional Permit for river channel maintenance.

- Review sand and gravel mining operations and integrate with TMDL development.

- Assign CWA Section 401 responsibility based upon type of project (road, stream restoration, etc.).

- Perform initial review and scheduling of permit revisions to coincide with TMDL development as feasible.

- Coordinate monitoring requirements for new permits with Regional Monitoring Program and MCWRA monitoring, if applicable.
- Coordinate inspections between staff as feasible.
- Consider watershed-level plans and monitoring, coordinated with TMDL development and the Regional Monitoring Program.
- Prioritize permitted sites and consider rescission of permits as feasible.
- Continue to manage underground storage tanks (USTs) in the Program-based unit; integrate the UST Program's water quality data with Regional Monitoring Program data in the long term.
- Determine the most efficient means of managing landfill regulation: either in a Program-based unit (similar to UST management), or by specialized staff within the watershed.
- Coordinate CEQA responses between the point and nonpoint source staff; use the existing standardized CEQA letter where appropriate.

TABLE ONE. SUMMARY SCHEDULE FOR TOTAL MAXIMUM DAILY LOAD DEVELOPMENT

SALINAS WATERSHED

303 (d) Listed Waterbody	Stressor	Date of TMDL Completion	Assess Further	Delist	Comments	TMDL Class
Blanco Drain[1]	Pesticides	4/2005				Primary/High
Espinosa Slough[1]	Nutrients	2/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Espinosa Slough[1]	Pesticides/Priority Organics	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Las Tablas Creek[1]	Mercury	4/2000				Primary/High
Las Tablas Creek, North Fork[1]	Mercury	4/2000				Primary/High
Las Tablas Creek, South Fork[1]	Mercury	4/2000				Primary/High
Moro Cojo Slough[1]	Pesticide	4/2011[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Moro Cojo Slough[1]	Siltation	4/2011[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Nacimiento Reservoir[1]	Mercury	4/2000				Primary/High
Old Salinas River Estuary[1]	Nutrients	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Old Salinas River Estuary[1]	Pesticides	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas Reclamation Canal[1]	Pesticides/Priority Pollutants	4/2005				Primary/High
Salinas River[1]	Nutrients	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River[1]	Pesticides/Priority Pollutants	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River[1]	Salinity	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River[1]	Siltation	4/2001[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River Lagoon (North)[1]	Nutrients	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River Lagoon (North)[1]	Pesticides	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River Lagoon (North)[1]	Siltation	4/2001[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River Lagoon (South)[1]	Nutrients	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River Lagoon (South)[1]	Pesticides	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Salinas River Lagoon (South)[1]	Salinity/TDS/Chlorides	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Tembladero Slough[1]	Nutrients	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High
Tembladero Slough[1]	Pesticides	4/2003[2]	X		Collect Water Quality Data by 3/2000	Primary/High

Santa Rosa Creek
Watershed Management Plan

Santa Rosa Creek
Watershed Management Plan

February 2012

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Appendices

Appendix A. Santa Rosa Creek Watershed Geomorphology Assessment
Appendix B. Santa Rosa Creek Benthic Macroinvertebrate Sampling Report
Appendix C. Public Meeting Questionnaire
Appendix D. Funding Resources

EXECUTIVE SUMMARY

The Santa Rosa Creek Watershed Management Plan was funded by California Department of Fish and Game's (CDFG) Fisheries Restoration Grant Program to develop a technically sound plan that addresses the strategic and scientific needs for watershed management, restoration planning, and south-central California coast steelhead (*Oncorhynchus mykiss*) recovery in the Santa Rosa Creek watershed, and that will be effective within current and foreseeable land use, water supply, and land ownership patterns in the watershed. Specifically, the objectives of the watershed management plan are to assess existing conditions, prioritize limiting factors for steelhead, and identify and prioritize restoration recommendations to address these limiting factors and improve physical functions and ecological conditions in the watershed. The watershed management plan was developed through the collaboration of a broad spectrum of participants. Stakeholders representing community sectors including agriculture, business, the community services district, planning advisory groups and fishing interests, and who work or live in the watershed, met periodically throughout the development of the watershed management plan to advise and inform the process, contribute historic and current information, assist in evaluating the accuracy of existing conditions and to review information and provide comments. In addition, a Technical Advisory Committee reviewed key watershed management plan elements, and input from the public was solicited at three public workshops.

Physical processes and ecological conditions in the Santa Rosa Creek watershed have been affected by historical clearing of land, groundwater pumping, urban development, bank revetment, historical mercury mining, land management practices, and road building. These activities have increased hillslope erosion and fine sediment supply to creek channels, resulted in channel incision, exacerbated low flows in the summer and fall, degraded riparian and aquatic habitat conditions, created barriers to fish migration, decreased water and sediment quality, and introduced non-native invasive species. Several of these effects limit the population of steelhead in the watershed by dramatically reducing instream flows in the summer and fall, decreasing pool habitat and large woody debris for summer and winter rearing, restricting their migration, and possibly limiting the potential for lagoon rearing.

The watershed management plan includes a suite of management, restoration, and study recommendations based on the synthesis of existing watershed conditions, steelhead limiting factors analysis, results of a geomorphic assessment and benthic macroinvertebrate sampling conducted specifically for the watershed management plan, and input from stakeholders and technical advisors. The recommendations present multiple ways to address steelhead limiting factors and conserve and improve physical processes and ecological conditions in the watershed, and are designed to be implemented individually, or in combination, on a voluntary basis, by or with the consent of willing landowners. Recommendations are presented by their ultimate objective and are listed in order of their relative importance to steelhead habitat restoration:

- Increase Summer and Fall Instream Flows
- Restore the Riparian Corridor
- Reduce Fine Sediment Delivery to the Creek
- Conserve and Protect Open Spaces and Existing Land Uses
- Increase Large Woody Debris Supply and Retention
- Remove Barriers to Fish Passage
- Fill Key Data Gaps
- Reduce Mercury Supply

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1 INTRODUCTION

1.1 Purpose of and Need for a Watershed Management Plan

Santa Rosa Creek in northern San Luis Obispo County once supported one of the largest populations of steelhead (*Oncorhynchus mykiss*) along the central California coast south of San Francisco (Titus et al. 2006). Perennial flow in most years, suitable instream habitat conditions (e.g., riparian cover and spawning substrate), and few physical barriers contributed to the success of this species in the watershed. However, recent fish studies have suggested that the population has dropped significantly below historic levels, driven by a number of probable factors including land uses and urbanization, road building, and groundwater and surface water management (e.g., Nelson 1994, D. W. Alley & Associates 2008, Nelson et al. 2009). In response to the concerns about existing habitat conditions for the threatened steelhead trout, several state and local advocacy groups began to identify limiting factors for steelhead trout habitat in the watershed (D. W. Alley & Associates 2008, TLCSLOC 2010) and implement stream habitat restoration projects (see Section 1.5).

Resource agency representatives responsible for recovering steelhead trout populations began to acknowledge the need to consolidate and unify these various efforts and provide a strategic and scientifically-based plan for improving steelhead habitat in Santa Rosa Creek. In 2008, California Department of Fish and Game (CDFG) awarded Greenspace – The Cambria Land Trust (Greenspace) grant funding to develop a comprehensive watershed management plan based on technical and local input that identifies limiting factors in the watershed and identifies and prioritizes restoration activities and can effectively restore creek function within current and foreseeable land use, water supply, and other constraints in the watershed. As the basis for these recommendations, the watershed management plan includes other recent information on watershed (e.g., climate, hydrology, and water quality) and steelhead population conditions. Acknowledging that there was a lack of understanding of physical factors that influence watershed conditions, the grant also included an investigation of the watershed's geomorphology —the scientific study of landforms and the processes that shape them (Section 2.5 and Appendix A). To better understand water quality conditions and their influence on aquatic biota, the grant included sampling of the benthic macroinvertebrate population as well (Section 2.8.4 and Appendix B). The purpose of this watershed management plan is to address the restoration needs for watershed management in the Santa Rosa Creek watershed by assessing existing conditions, identifying limiting factors for steelhead, and identifying and prioritizing restoration recommendations to improve physical and ecological conditions and facilitate the recovery of steelhead in the watershed.

What are your concerns about the creek and watershed?

"I would hope for a cooperative effort that results in a healthy watershed."
– *Public Meeting Participant*

1.2 Goals and Objectives

The objectives of this watershed management plan are to:

- Document historical watershed conditions.
- Assess physical and biological conditions in the watershed.
- Determine factors limiting the steelhead population.
- Identify and prioritize actions to address limiting factors for steelhead.
- Recommend additional actions that will improve overall fish and wildlife habitat.

The goals of the watershed managements planning process are to:

- Provide a thorough compilation of historical and current conditions in the Santa Rosa Creek watershed and assessment of steelhead limiting factors.
- Provide opportunities to educate the community on watershed conditions and ecological processes.
- Build local support for and participation in watershed conservation and restoration.
- Provide a supporting document so that willing participants can seek funds for recommended steelhead projects from CDFG's Fisheries Restoration Grant Program.

1.3 Overview of the Watershed

Looking up the Santa Rosa Creek watershed

Santa Rosa Creek watershed lies within the southern portion of the California Coast Range—a northwest-trending series of mountains and basins along the coast from Santa Barbara north to the Oregon border (Figure 1-1). The 48 mi^2 (123 km^2) watershed is bounded to the east by the Santa Lucia Mountain range and the west by the Pacific Ocean. Bordering the watershed are the similarly sized watersheds of San Simeon Creek to the north, Adelaida Creek to the northeast, Paso Robles Creek to the east, and Villa Creek to the south. Santa Rosa Creek and its tributaries flow mostly unobstructed down steep hillslopes mantled with shallow soils and sparse shrub vegetation and through agricultural areas and the small town of Cambria before reaching the Pacific Ocean. Santa Rosa Creek travels 16 mi (25 km) from its headwaters, following a sinuous course to the west through a confined canyon that opens up into a relatively long, broad valley floor. The town of Cambria sits near the mouth of Santa Rosa Creek, downstream of the confluence with Perry Creek—the largest tributary in the watershed. Only four creeks have been named on topographic maps of the U.S. Geological Survey (USGS)—Santa Rosa, Perry, Green Valley, and Fiscalini creeks (USGS 1979a, 1979b), while an additional six streams have been unofficially designated as derived from past or current property owner names (e.g., D. W. Alley & Associates 2008). These tributaries are referenced throughout this report, as summarized below in Table 1-1 and shown in Figure 1-2. The topographic relief is typical of the southern Coast Range terrain, with steep upland areas and low-gradient valley bottoms bordering the lower reaches of Santa Rosa, Green Valley, and Perry creeks (Figure 1-2). Relatively higher elevations are present in the Santa Rosa Creek sub-watershed, which peaks at Cypress Mountain with an elevation of 2,933 ft (894 m). In comparison, the highest point in the Perry Creek sub-watershed (NE corner of the Green Valley sub-watershed) reaches an elevation of 1,419 ft (433 m). At its lowest elevation, Santa Rosa Creek flows through a lagoon contained by an annually formed sandbar at Moonstone Beach that breaches when streamflow begins to rise and ocean wave action increases in late fall.

Table 1-1. Santa Rosa Creek watershed and sub-watershed areas and stream lengths.

Sub-watershed [a,b]		Tributary location [c]		Area [d]		Stream length [e]	
USGS-designated stream name	**Unofficial stream name**	**mi**	**km**	**mi^2**	**km^2**	**mi**	**km**
Santa Rosa Creek [f]		n/a	n/a	24.6	63.6	15.8	25.4
Unnamed	*Taylor Creek*	3.5	5.6	2.4	3.8	2.4	3.8
Unnamed	*Curti Creek*	7.5	12.1	2.1	5.5	2.2	3.5
Unnamed	*Lehman Creek*	9.7	15.6	2.5	6.5	2.6	4.1
Unnamed	*East Fork Santa Rosa Creek* [g]	12.1	19.5	1.9	4.9	2.9	4.7
Unnamed	*North Fork Santa Rosa Creek* [h]	12.5	20.1	2.2	5.6	2.6	4.2
Unnamed	*Mora Creek*	12.5	20.1	2.6	6.8	3.0	4.8
Perry Creek		3.0	4.8	22.9	59.3	9.7	15.6
Fiscalini Creek		5.2	8.4	2.6	6.7	1.4	2.3
Green Valley Creek		6.0	9.7	12.2	31.5	7.9	12.8
Total Santa Rosa Creek Watershed				**47.5**	**123**	**15.8**	**25.4**

[a] Tributaries are indicated by the degree of text indentation (e.g., Taylor Creek is a tributary to Santa Rosa Creek, Green Valley Creek is a tributary to Perry Creek which is a tributary to Santa Rosa Creek).

[b] To help identify unnamed tributaries on USGS topographic maps (USGS 1979a, 1979b) that are referred to later in this document unofficial tributary names from D.W. Alley & Associates (2008) are also presented.

[c] Locations of Taylor, Curti, Lehman, East Fork Santa Rosa, North Fork Santa Rosa, and Perry creeks are based on the longitudinal station at which they enter mainstem Santa Rosa Creek, starting at the Santa Rosa Creek mouth. The location of Mora Creek is based on the longitudinal station at which it enters North Fork Santa Rosa Creek upstream from mainstem Santa Rosa Creek. Locations of Fiscalini and Green Valley creeks are based on longitudinal stations along Perry Creek upstream from mainstem Santa Rosa Creek.

[d] Sub-watershed area derived in a GIS using a USGS 10m Digital Elevation Model (DEM).

[e] Stream length derived in a GIS using a USGS 10m DEM-generated stream network with a contributing area threshold of 0.04 km^2.

[f] Santa Rosa Creek mainstem continues along the unofficially named "East Fork Santa Rosa Creek" per the USGS stream designation (USGS 1979b).

[g] This creek is also commonly known as Soto Creek (D. Dunlap, pers. comm., 2009).

[h] This creek is also commonly known as Macacci Creek (D. Dunlap, pers. comm., 2009).

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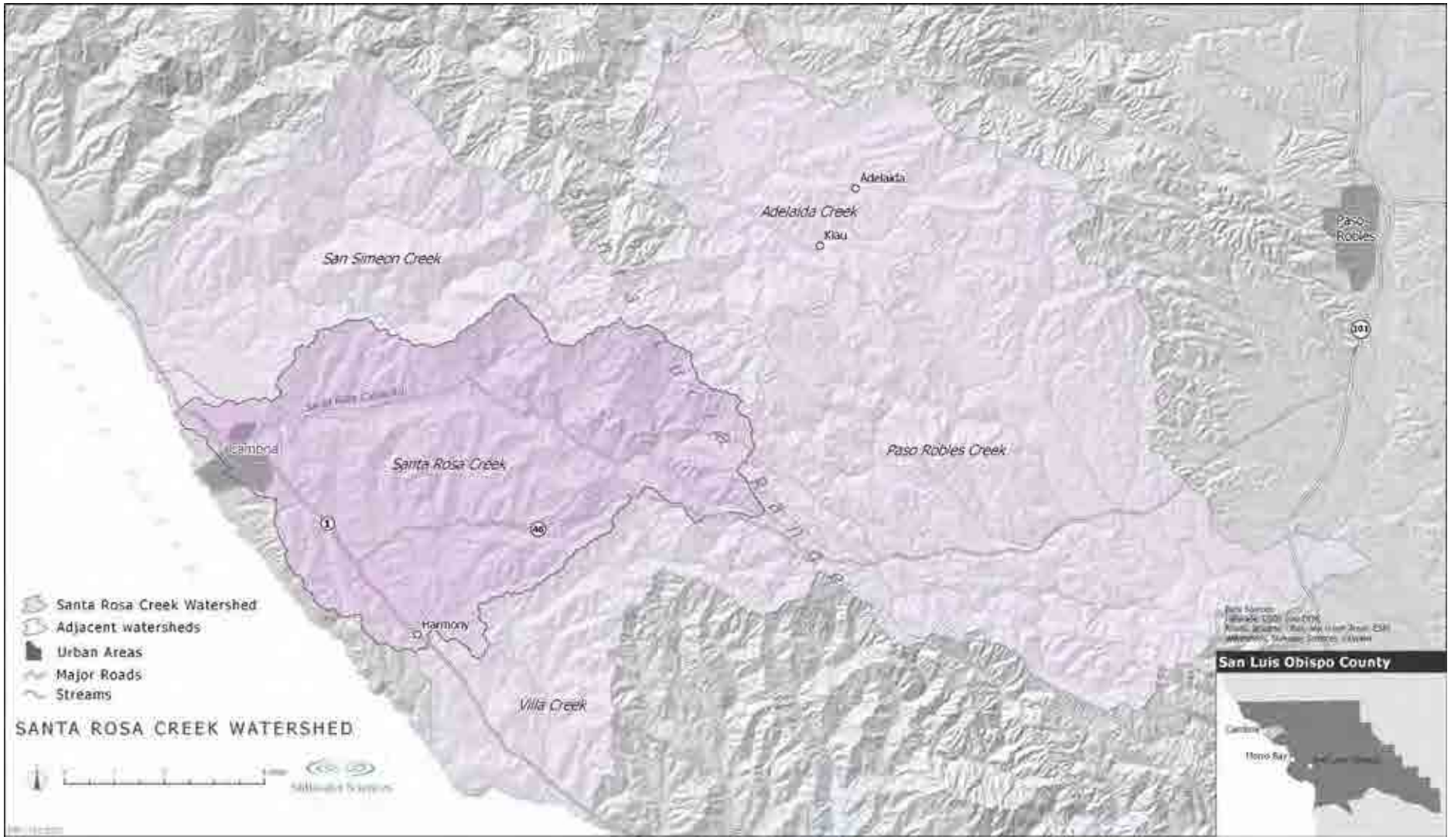

Figure 1-1. Santa Rosa Creek watershed and vicinity map.

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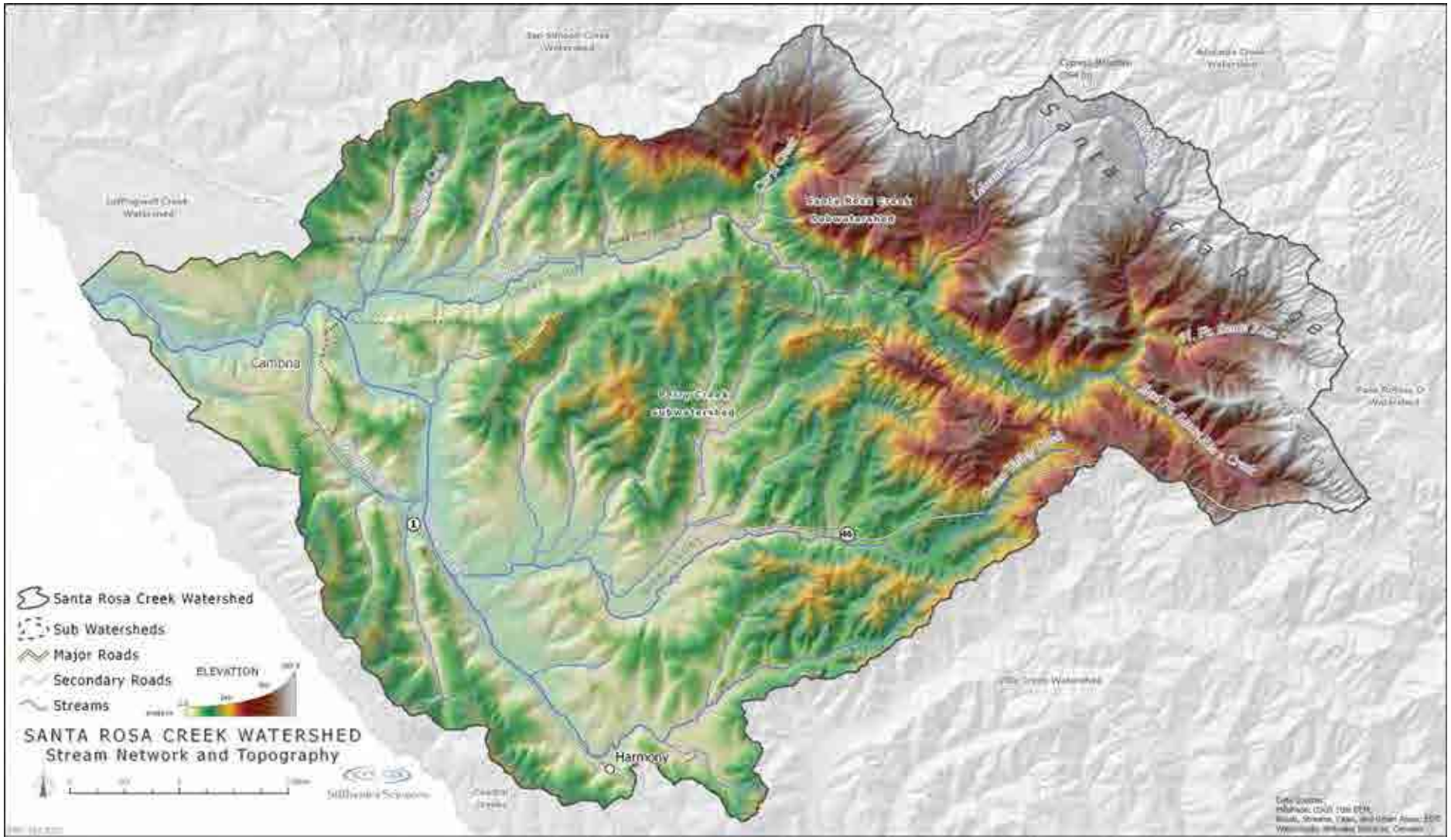

Figure 1-2. Santa Rosa Creek watershed stream network and topography.

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1.4 Stakeholder Involvement in the Watershed Management Plan

Recognizing that the development of a watershed management plan requires understanding and embracing the needs and concerns of local landowners, water users, and industry, the watershed management plan included the establishment of a stakeholders group. The role of stakeholders in formulating the watershed management plan is central to the success of its development and implementation, and their willingness to share information to shape the context of issues, marks a plan that will live beyond its written pages.

Stakeholders representing the various sectors that exist in the watershed, including agriculture, business, the community service district, planning advisory groups and fishing interests, were recruited to participate in the development of the watershed management plan. All stakeholders either work or live in the watershed. Stakeholders met periodically to contribute historic and current information, assist in reviewing the accuracy of existing conditions and other information, and provide comments. In addition, each stakeholder meeting included educational opportunities to offer background on a variety of topics related to steelhead ecology and watershed restoration, and increase awareness of and appreciation for the way in which watershed residents and businesses could voluntarily engage in restoration activities. Stakeholders' time and effort are recognized as being the cornerstone of continuing efforts to address factors limiting steelhead in the Santa Rosa Creek watershed, and are acknowledged throughout this document, as well as in the acknowledgements section at the end of this document (Section 5). Stakeholders met eight times between September 2009 and March 2011, representing a total of 240 person-hours, not including the time spent reviewing documents.

What are your concerns about the creek and watershed?

"Sustainable management of water for environment and people; enhance the productivity of ecosystem services of the watershed."

– Stakeholder

A Technical Advisory Committee (TAC) was convened to review and provide input to the watershed management plan to ensure that the data, analyses, and recommendations in the watershed management plan are correct, appropriate, and in keeping with local, regional, state, and federal efforts. TAC members are listed in the acknowledgements section at the end of this document.

In addition to stakeholders, the public was invited to attend three meetings during the course of the watershed management plan's development to facilitate information feedback between the TAC and the larger community and to provide a forum for education. The first meeting, held in January 2010, introduced the project to the public and sought input through a written questionnaire (Appendix C). The second meeting in August 2010 provided the public with a summary of watershed conditions. The third meeting in March 2011 unveiled the final watershed management plan and formally expressed gratitude to the community and stakeholders for their contributed time and effort.

1.5 Related Studies and Management Actions in the Watershed

A number of watershed management and restoration studies and/or actions have and are being conducted in the Santa Rosa Creek watershed. Several of these provided the impetus for this watershed management plan, while others support it by improving watershed conditions and incorporating a broad range of community members in the conservation and restoration of the watershed.

The Land Conservancy of San Luis Obispo County (TLCSLOC) recently completed the *Santa Rosa Creek Watershed Conservation Plan* (TLCSLOC 2010). The conservation plan compiled an extensive set of existing data for the watershed, collected additional data on upland erosion, and presents conservation strategies based on Natural Resources Conservation Service and California Rangelands resources. The synthesis of existing watershed conditions in this watershed management plan relied in part on the data compiled and collected by TLCSLOC (2010).

Rathbun et al. (1991) documented the status of four special-status declining reptiles, amphibians, and fishes in lower Santa Rosa Creek, which provided much of the basis for the *Lower Santa Rosa Creek Enhancement Plan* (Prunuske Chatham Inc. 1993). The lower creek plan, which was completed in 1993, described the ecological conditions and presented a plan for enhancing the reach of the creek from the Main Street Bridge to the ocean (Prunuske Chatham Inc. 1993). This watershed management plan updates and geographically expands upon the lower creek plan, and incorporates several of its enhancement measures.

Riparian buffer between Santa Rosa Creek and adjacent farmland

Many property owners in the watershed are already protecting watershed resources by implementing best management practices, and several local organizations, including Greenspace, the Cambria Community Services District (CCSD), Friends of Fiscalini Ranch Preserve, Cambria Forest Committee, and others, have completed enhancement, monitoring, and educational projects and events in the watershed. These have included:

- Water quality monitoring snap shot days (ongoing, approximately annually)
- Beach and creek cleanups (ongoing, annually)
- Ferrasci Road barrier removal (2011)
- Non-native eucalyptus tree removal downstream of Highway 1 (2010)
- Steelhead habitat enhancement, bank stabilization, and educational signs downstream of the Highway 1 Bridge (2007/2008)
- Burton Street Bridge barrier removal (2006)
- Fiscalini streambank stabilization (2005)
- San Luis Obispo County stream crossing inventory and fish passage evaluation (2005)
- Cambria forest management plan (2002)
- Santa Rosa Creek is Your Watershed educational program (2002)
- Watershed and Cambria forest conferences (2002 and 1991)

2 SYNTHESIS OF WATERSHED CONDITIONS

2.1 Historical Watershed Conditions and Watershed Impacts

Looking at a watershed's past provides insight into natural physical and ecological trends in addition to the identification of human-induced changes over time. An informed forecast of future watershed conditions can therefore be made based on synthesizing the understanding of past and present conditions. The information presented in this section summarizes general historical conditions in the watershed dating back to pre-European settlement in an attempt to illuminate the historical (both natural and human-induced) events that may have had an effect on physical processes and ecological conditions in the watershed (Figure 2-1).

Prior to European settlement along the California coast, the watershed is assumed to have been in a relatively undisturbed condition, responding only to fluctuating flood, drought, earthquake, and fire sequences, and with relatively minor impacts associated with the hunting and gathering practices of the local indigenous peoples. The first recorded accounts of Santa Rosa Creek valley are those made during the Portola Expedition where, in September 1769, the party encountered a "canyon… and arroyo[1] surrounded with hills of pine" (Hamilton 1974). On numerous instances, the expedition party noted flowing streams, both along what is now known as the mainstem Santa Rosa Creek and from many of its "springs", or tributaries (Hamilton 1974). Few other records of this area's natural resources were made for several decades despite the establishment of Mission San Miguel (1779) near present-day Paso Robles and the growing use of the Santa Rosa and San Simeon watershed areas for timber and wild game to support the Spanish population throughout the southern Coast Range region.

In 1840, Don Julian Estrada was granted possession of Rancho Santa Rosa—a 13,200-ac (53-km^2) land holding encompassing a portion of the western half of the watershed (Angel 1883, Hamilton 1974). Estrada drafted an illustration of his land in that year that depicts several notable features of the historical landscape, including Santa Rosa and San Simeon creeks draining to the ocean from steep upland areas, continuous pine forests upon hillsides surrounding lower Santa Rosa Creek near the area of present-day Cambria, a coastal trail parallel to the coastline, and, perhaps most interestingly, a "laguna", or lake along the narrow valley of lower Perry Creek (Figure 2-2). This lake is further described in Hamilton (1974) as a "shallow, broad lake… clogged with tules" fed by both Perry and Green Valley creeks, and bordered along its eastern shore by a coastal trail linking San Luis Obispo with San Simeon. The exact location of this lake is not precisely known, but it has been estimated to have formerly extended from the Perry and Green Valley creeks confluence north towards Santa Rosa Creek (Hamilton 1974; D. Dunlap, pers. comm., 2009). The lake was eventually drained by "Walker Ditch" in the early 1870s under the direction of the second owner of this portion of Rancho Santa Rosa, George Hearst, for the purpose of converting the wetland area to agricultural land (Hamilton 1974; D. Dunlap, pers. comm., 2009). The first official survey map of San Luis Obispo County published in 1874 does not depict the lake, indicating that it had already been drained when the survey was conducted, and instead shows a stream channel that generally follows the present-day stream course of lower Perry Creek (Harris 1874) (see Appendix A). Today, this artificial stream course of lower Perry Creek stands out from all other stream courses in the watershed as it follows long, straight segments connected by right-angle turns along the valley floor and north towards its confluence with Santa Rosa Creek.

[1] The Spanish word of "arroyo", as used in this account, translates to mean a small creek and not one that is necessarily incised, which is unlike the contemporary use of the word in the English language to mean an incised creek, typically those found in the American southwest.

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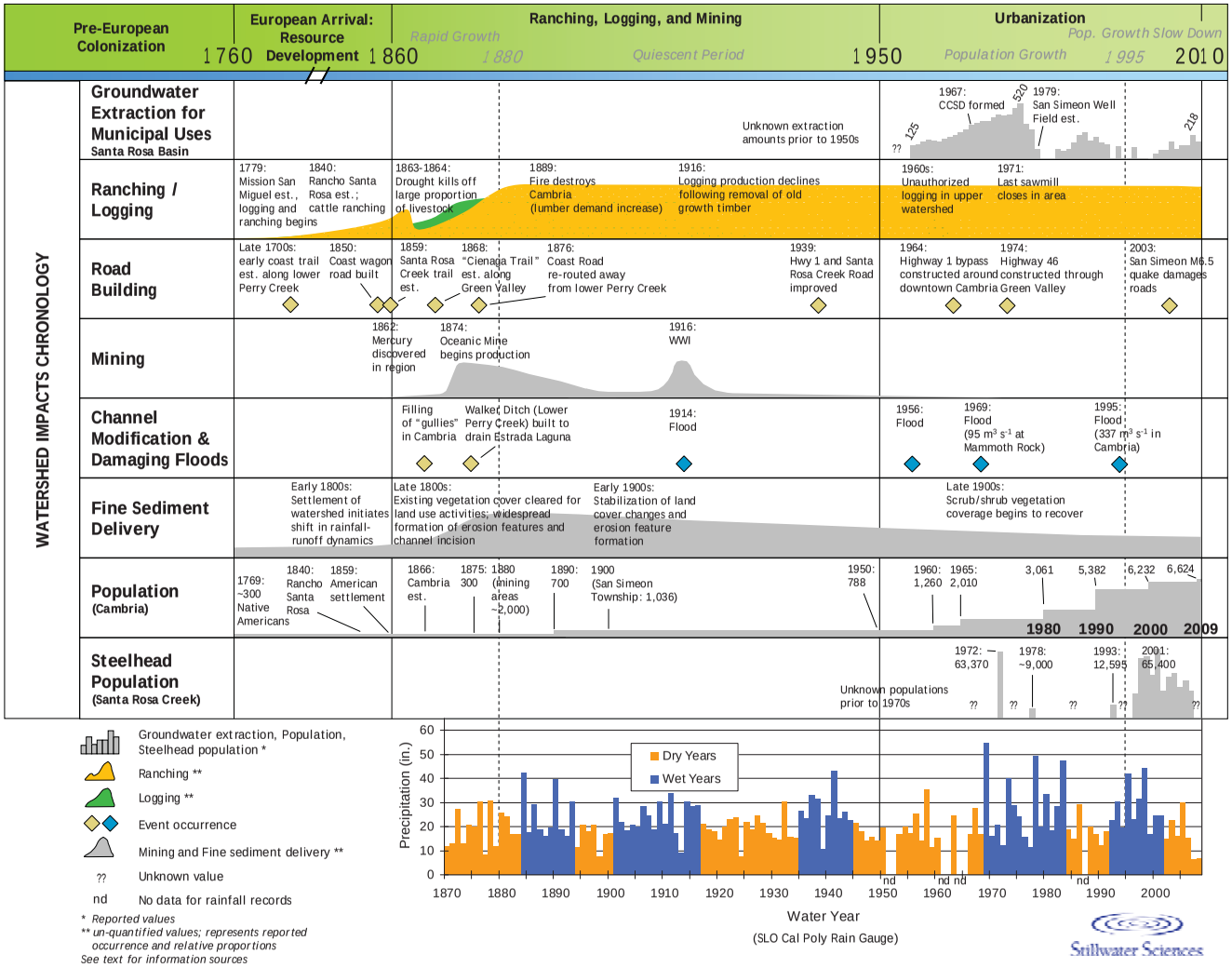

Figure 2-1. Chronology of watershed impacts and events. Precipitation records indicate periods of cumulatively wetter (blue) and drier (orange) periods in the watershed.

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The lagoon likely functioned as a settling basin for sediment delivered by tributaries of Perry Creek, and effectively served historically to separate the Perry Creek sub-watershed from the Santa Rosa Creek sub-watershed in terms of sediment delivery, especially of coarse sediments.

Figure 2-2. Illustration of Rancho Santa Rosa by Don Julian Estrada as part of his 1841 land grant application. Source: Coffman 1995.

In the early 1800s, clearing of the land in support of agricultural activities—cattle ranching, crop cultivation, and logging—likely caused significant changes to rainfall-runoff relationships as trees, shrubs, and deep-rooted native perennial grasses in the valleys and upon hillslopes were degraded and replaced by shallow-rooted, non-native annual grass species that less effectively protect soil against erosion. Initially, cattle herds from Mission San Miguel were occasionally moved into the Santa Rosa Creek watershed because of ample sources of water and foraging vegetation even during the dry seasons (Hamilton 1974). Starting in the late 1850's, Americans and European immigrants began settling the watershed and greatly increased the pace of land clearing, which was reportedly achieved by cutting and/or burning the native vegetation (Coffman 1995; D. Dunlap, pers. comm., 2009). Historical accounts from across the coastal region tell of coordinated efforts by land owners to clear valley-bottom forests along major rivers (Boughton et al. 2006), which was likely practiced along Santa Rosa, Perry, and Green Valley creek valleys as very little forest cover remains but for some riparian stands closely bordering the stream channels (see Appendix A). Overall, these land uses coupled with episodic storm events resulted in several significant changes in the watershed, namely: (1) greater volumes of hillslope runoff generated per unit rainfall, with far greater volumes of fine sediment production throughout the watershed and increased gullying and shallow landslide potential on the steeper hillslopes; and (2) incision of the mainstem stream channels due to decreased stream bank stability and increased stream power allowing high flows to entrench the channel. Prior to incision, the Santa Rosa, Perry, and Green Valley creek channels would have supported higher groundwater elevations and more frequent inundation under lower flows, which supported the valley forests.

Between 1865 and 1885, a period of population growth and land development occurred in the watershed. Despite a die-off of beef cattle during the intense 1863–1864 drought, a shift to dairy farming, continued logging, and mining of cinnabar for mercury in the region maintained a steady rate of landscape alteration over the next two decades. Urban development and road building began the process of filling in small stream channels, especially those situated near Cambria (Hamilton 1974). By 1880, the landscape had been radically changed from its pre-European settlement condition and appeared very similar to present-day conditions, as represented in several illuminating sketches made during the 1870s (Angel 1883) that show grass-covered hillslopes and valley floors used for pasture with some relict patches of native riparian vegetation remaining near stream channels (Appendix A). Another notable feature depicted in two of these

DeNise ranch, residence, and dairy in the Santa Rosa Creek watershed, circa 1880 (Angel 1883)

illustrations is active hillslope erosion in the form of gullies, which remains a ubiquitous feature of the present-day landscape.

Beginning in 1874, cinnabar, the common ore of mercury, began to be mined at the Oceanic Mine in the Curti Creek sub-watershed. During peak production, ore was milled and processed into pure forms of mercury in a furnace located approximately ½-mile downhill from the mine (Eckel et al. 1941, as cited in CCRWQCB 1999). Mining production continued on and off through the 1900s, with a second peak around 1916 in support of World War I efforts (Hamilton 1974, Baker 2003). While land clearing, road building, and excavation associated with the mine likely resulted in increased fine sediment supply to Curti Creek and downstream, the mine's most deleterious impact has been to water quality. Iron-rich, red seepage from the mine and erosion of mercury-rich waste rock at the former mill site continue to pollute and discolor Curti Creek for most of the downstream distance to Santa Rosa Creek (CCRWQCB 1999, CDPH 2009).

Between 1920 and 1940, the rate of new land development leveled off as mining and logging operations declined, along with the transient population that supported those industries. These trends were driven, respectively, by falling mercury prices and by the near-depleted stock of old growth pine trees (Hamilton 1974). Through this period, dairy farming and crop cultivation continued, but likely did not increase in extent. In general, the landscape condition present during this period appeared very similar to the present-day condition (Appendix A). However, despite these seemingly unchanged conditions in many areas of the watershed, significant changes to specific areas did occur after this relatively quiescent period in the watershed's post-settlement history. The only available records of fish stocking in the watershed occurred during this time. Titus et al. (2006) cite a 1933 record of approximately 4,000 brown trout and a 1951 record of approximately 3,000 rainbow trout being planted in the watershed.

Starting in 1960 and extending through to the mid-1990s, the town of Cambria experienced a steady increase in population and, correspondingly, an increase in urban development in the form of new housing, commercial, and some industrial developments as driven by their tourism industry. According to County and U.S. Census data, Cambria's population (excluding the remainder of the watershed) increased from 788 to 5,382 between 1950 and 1990, representing 6.8-fold increase, while California as a whole experienced only a 2.8-fold increase. Recent population growth in Cambria since 2000, however, dropped considerably to only a 1.1-fold increase, which is below the state growth rate during the past decade (A. Ochs, pers. comm., 2009; U.S. Census Bureau 2003, 2009). This population growth slowdown period signifies stabilization not only of the Cambria population but also of development that would expand the town's urban footprint in the watershed.

The urbanization time period between 1960 and the 1990s also represented an expansion of groundwater pumping and stream diversions to irrigate crops and to provide drinking water to Cambria, which has reduced base flows in Santa Rosa Creek, and potentially within Perry and Green Valley creeks as well. A lowered groundwater table has led to subsidence in areas of the lower Santa Rosa Creek valley, which was observed in Cambria during 1976—the year with the highest municipal groundwater extraction (Yates and Van Konyenburg 1998). Groundwater lowering may have led to further degradation of mature riparian vegetation (in areas where riparian vegetation was not replaced by crops), which is reliant primarily on groundwater during the summer dry season. Large floodplain areas with extensive riparian vegetation may have attenuated floods within Santa Rosa Creek; the removal and degradation of large riparian stands would have therefore increased the "flashy" nature of flood events (i.e., higher flows over a shorter time period). Indeed, large floods in 1914, 1956, 1969, and 1995 have damaged properties situated upon floodplain areas (Hamilton 1974; D. Dunlap, pers. comm., 2009). As a result, bank revetments, or riprap, were subsequently installed along some reaches of Santa Rosa Creek near Cambria to protect floodplain developments from future flood-induced bank erosion. To date, however, no levees have been constructed along the creek or its tributaries, although Highway 1 serves as a low-lying berm to the west of downtown Cambria.

A very significant impact to the watershed from 1960 to the 1990s is the construction of roads; Highways 1 and 46, and Santa Rosa Creek Road. Each of these roads has altered runoff patterns as it traverses the landscape. The first trails and roads in the watershed closely followed the contours of the natural terrain. Their impact was likely limited only to vegetation removal and fine-sediment run-off. The present-day route of Santa Rosa Creek Road primarily follows the original wagon road from Cambria and east towards Paso Robles (Harris 1874, Hamilton 1974) and was paved in 1939. While paving may limit fine-sediment runoff from the road surface, it may also concentrate flow drainage near the stream channel and cause gullies to form on the out-board side of the road and into the creek. The route taken today by Highway 1 differs from that traced by the original "coast road" (Harris 1874, Hamilton 1974) and was cut into hillslopes and laid across small streams channels with culverts. Many of the culverts in the watershed have become partial if not complete barriers to fish migration and movement (see Section 2.7).

Completed in 1974, Highway 46 travels through Green Valley and is the most recent roadway constructed in the watershed, involving relatively large cut and fill sections that allow for a nearly straight path through the varied topography. The need for an extensive series of fill embankments and cuttings for Highway 46 greatly increased rates of fine sediment input to Green Valley Creek during and shortly after construction, and has led to on-going problems of embankment and culvert-related erosion, as well as accelerating runoff into Green Valley Creek. In addition, upper Green Valley Creek and numerous small streams have been virtually cut-off from lower Green Valley Creek, but for the presence of some culverts. Under normal circumstances, water may be conveyed completely through these culverts, but coarse sediment and large woody debris deposited at the culvert entrance during high flows causes blockages that deny the replenishment of gravel and cobble substrates and woody debris in the lower reaches. This adversely affects not only the channel morphology of Santa Rosa Creek but also the availability and complexity of steelhead trout habitat (D. W. Alley & Associates 2008, Nelson et al. 2009). An additional negative of all three major roadways in the watershed has been their effect on erosion associated with concentrating runoff towards the downslope side of the roads (see Section 2.7).

As stated above, the most recent time period between the mid-1990s and present day is generally characterized by a population growth slowdown and, accordingly, a reduction in additional urban development that would act to further alter the landscape, physical processes, and ecological

conditions the watershed (see Section 2.2.4). This period also marks the initiation of several endeavors to restore ecologic and geomorphic function in Santa Rosa Creek, including the removal of fish passage barriers and bank-repair projects (see Section 1.5).

2.2 Land Use

2.2.1 Current land uses

The majority of the Santa Rosa Creek watershed is sparsely populated, with urban development concentrated downstream at the town of Cambria. As of 2009, the town supported a population of 6,624 (Cambria Chamber of Commerce, pers. comm., 2009). The remainder of the watershed is almost entirely under agriculture, with primary activities consisting of cattle ranching and limited crop cultivation, which require some level of water usage, primarily obtained via groundwater pumping. In Cambria, developments consist of a business district, which closely borders the lower 2.8 mi (4.5 km) of Santa Rosa Creek from Main Street Bridge to the lagoon area, and residential neighborhoods that extend to the north and south upon the adjacent hillsides. Tourism, primarily directed towards visitors traveling to Hearst Castle in nearby San Simeon, is the chief industry of Cambria. As of 2001, developed areas account for approximately 8% of the watershed area (Homer et al. 2004). Besides the town of Cambria, the only other significant elements of infrastructure in the watershed include three roadways: Highway 1, Highway 46, and Santa Rosa Creek Road. The roadways closely follow and occasionally cross, via bridge or culvert, portions of Santa Rosa, Perry, and Green Valley creeks.

Field ready for planting

2.2.2 Land use planning

The Santa Rosa Creek watershed is entirely within the unincorporated area of the County of San Luis Obispo, where current land use decisions and long range planning are governed by the County's General Plan Land Use Elements and Local Coastal Program. The overarching land use and resource management planning tools embedded in the Land Use Elements include the Resource Management System, the Framework For Planning (Inland) (2009), Coastal Zone Framework For Planning (1993), and Planning Areas. Two Planning Areas, separated by the Coastal Zone Boundary (Figure 2-3), cover the Santa Rosa Creek watershed: the North Coast Planning Area, which is governed by both the Coastal Act and County's General Plan Local Coastal Program, and the Adelaida Planning Area, governed by the General Plan.

The lower half of Santa Rosa Creek watershed is within the rural North Coast Planning Area (Figure 2-3, Coastal Zone Boundary), which covers 165,300 ac (668 km^2) along the San Luis Obispo County coastline, approximately 77,000 ac (311 km^2) of which are owned by the Hearst Corporation. Cambria is one of only two urban areas in the North Coast Planning Area (the other is San Simeon Acres in the San Simeon Creek watershed). Aside from two small commercial/retail parcels on Hearst Corporation property, the entire North Coast Planning Area is designated as agriculture, with two relatively small areas of rural land use north of Cambria and on the border of Monterey County. Table 2-1 summarizes the types of development projects completed between 2003 and 2008 in the North Coast Planning Area (outside the urban areas of Cambria and San Simeon Acres).

The upper half of the watershed is within the Adelaida Planning Area, which covers 208,008 ac (842 km^2) and borders the cities of Paso Robles, Atascadero and Morro Bay and the communities of Cayucos and Templeton. In 1990, the Adelaida Planning Area was extended over the ridge of the Santa Lucia range and onto the western coastal slope of the upper Santa Rosa Creek watershed. Table 2-1 summarizes the types of development projects completed between 2003 and 2008 in the Adelaida Planning Area.

As shown in Figure 2-3, the vast majority of land in the watershed is designated agriculture with small parts of the upper watershed designated as rural lands. A number of urban development types are allowed in these land use categories, including wineries and tasting rooms, bed and breakfasts, retail sales, restaurants, veterinary hospitals, residences, sale of farm equipment and supplies, camping, certain types of manufacturing, and communication facilities (San Luis Obispo County 1993).

Table 2-1. Completed development projects in the Adelaida and North Coast Planning Areas [a] of San Luis Obispo County between 2003 and 2008.

Type of development	Adelaida Planning Area [b]							North Coast Planning Area [b]						
	2003	2004	2005	2006	2007	2008	Total	2003	2004	2005	2006	2007	2008	Total
Winery facility	1	10	2	4	9	10	36	0	0	0	0	0	0	0
Misc. commercial	0	2	0	0	1	2	5	0	0	0	1	0	0	1
Commercial/ industrial addition/alteration	2	4	1	7	3	2	19	2	2	0	0	0	2	6
Farm support quarters	0	1	0	0	0	0	1	0	0	0	1	0	0	1
New single family dwelling	3	19	12	12	24	15	85	0	3	5	4	1	3	16
Guesthouse	1	2	3	1	4	2	13	0	0	0	2	0	0	2
Secondary dwelling	0	0	1	1	0	1	3	0	0	0	0	0	0	0
Mobile home	2	6	9	8	1	11	37	1	0	0	1	1	1	4
Swimming pool/spa; resident. & comm.	3	5	5	7	7	8	35	0	0	0	0	0	1	1
Radio/cell tower	0	0	2	1	2	1	6	0	1	1	0	0	0	2
Wind/solar system	0	5	4	14	11	18	52	0	1	1	0	1	3	6

[a] The Coastal Zone is the boundary between these two planning areas (Figure 2-3).
[b] Source: Permit Tracking Summaries 2003–2008, accessed at: www.slocounty.ca.gov/planning/Permits/

2.2.3 Growth trends in San Luis Obispo County

The 2008 Growth Assessment states that between 2000 and 2007, two of every five new homes built in the unincorporated County were built in rural areas outside of the urban communities. If this trend continues, the County estimates that population in the rural areas of the County will increase by 7,900 to 15,800 individuals by 2030. According to the County's 2006 General Plan Annual Progress Report, the Adelaida Planning Area is projected to see a population increase of 2,241 between 2010 and 2030. Table 2-1 of completed projects in the Adelaida Planning Area from 2003 through 2008 shows a trend toward water-intensive wineries and residential uses. To date, however, that development has occurred primarily on the eastern side of the Santa Lucia range on rural lands outside the urban areas of Paso Robles, Templeton, and Atascadero.

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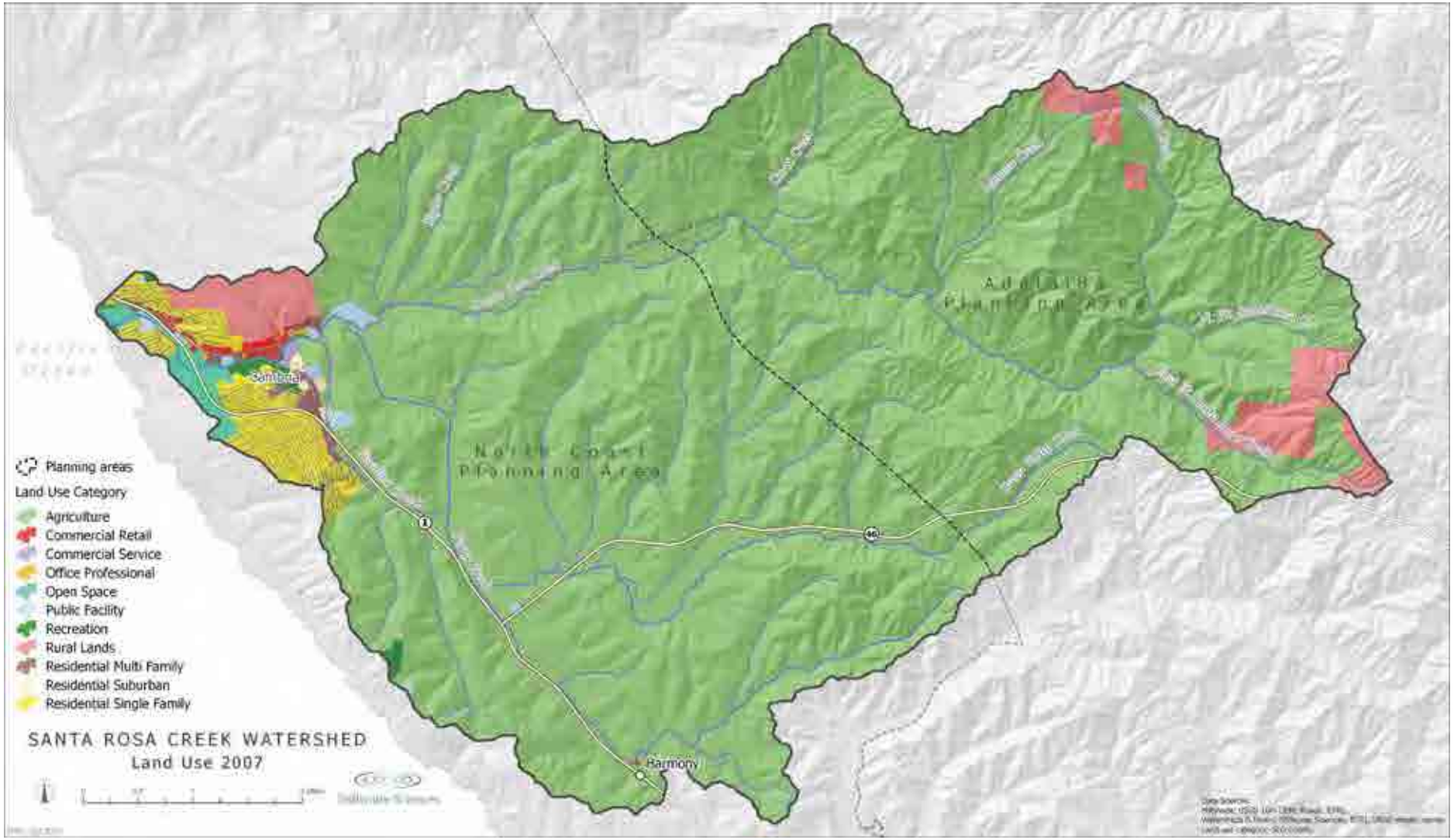

Figure 2-3. Land uses within the Santa Rosa Creek watershed.

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A steady increase in the numbers of people choosing to live in the rural areas of the County is fueled in part by the existence of underlying antiquated subdivisions[2], of which there are over 3,500 in the unincorporated County area. Many of these parcels are capable of being developed through the process of obtaining certificates of compliance (legal documents that certify compliance of an underlying parcel with the California Subdivision Map Act). And while in 1977 approximately 80% of these parcels were farmed or grazed with only a small fraction of the parcels developed at that time, since the year 2000 over 600 of these parcels have been developed with homes (San Luis Obispo County 2009).

2.2.4 Rural to urban conversion

City and Regional Planning research indicates that there is a typical sequence to land use changes over time as rural lands are converted to urban uses (Briassoulis 2000). Portions of the lower Santa Rosa Creek watershed exhibit this shift, as large ranches have been subdivided and converted to dairy and row crops and urban land uses. This conversion can degrade the quality of watershed resources and it is often the degree and balance of disturbance in urban land uses versus rural that is of consequence. Said differently, rural land use development may impact watershed health in a dispersed manner whereas urban influences are more concentrated.

As rural lands are developed, shifting from grazing to intensified agriculture and/or urban uses, water consumption generally increases, rainfall runoff volume and velocity increase as impervious surfaces increase, groundwater recharge/infiltration decreases, bank erosion and channel incision may increase, and tributary and mainstem peak flow volumes, and therefore flood risk, increase during the rainy season. In the dry season, base flow is reduced as groundwater is pumped year-round.

Although urbanization in the Santa Rosa Creek watershed is limited to the relatively small community of Cambria and surrounding neighborhoods, several of the impacts associated with land use shift have been documented in the lower watershed. These include increased municipal water demand that can reduce instream flows (see Section 2.6), additional instream infrastructure that reduces habitat quality (see Section 2.7), and increased rainfall runoff and associated impacts to water quality and drainage (see Section 2.8). Urban development of the watershed has been limited by land use planning regulations and water supply (see Section 2.2.5 below), and is constrained to the downstream end of the watershed, where the ill effects associated with urbanization are limited to a small portion of the watershed. Changes in land use controls could, however, lift some of the current constraints to urbanization (see Section 2.2.5 below). It will be important to recognize and prevent or mitigate land use changes that could exacerbate the ill effects associated with urbanization or promote the expansion of such land use changes further up the watershed.

2.2.5 Land use controls

While a portion of the lower watershed has already been developed, outside of this area the pattern of rural to urban land use conversion is currently limited in the majority of the Santa Rosa Creek watershed. This is due to a variety of planning related factors, such as the Coastal Act, Local Coastal Program, Williamson Act, and agricultural and rural land use designations that limit development, and physical factors, such as the limited supply of water and road access to

[2] Underlying antiquated subdivisions are parcels created before modern land-use planning laws. These parcels underlay larger parcels created by the California Subdivision Map Act and they are antiquated because they were created before the Map Act was passed.

most of the watershed. Several of these land use control are, however, at risk of being lifted, which could increase the conversion of rural land uses to intensified agriculture and/or urban uses and, as described above, result in serious impacts to the ecological conditions of the watershed.

A major difference in land use controls within the two planning areas of the watershed is the resource protections provided by the California Coastal Act and the Local Coastal Program that apply only to the lower watershed in the North Coast Planning Area (see Figure 2-3). The Coastal Act requires protection of agricultural resources and environmentally sensitive habitat areas and provides an additional layer of development permit review by the California Coastal Commission. In addition, land use plans in the coastal zone must be consistent with the resource protection requirements of the Coastal Act and must be certified by the Coastal Commission. By contrast, the upper half of the watershed is not subjected to the same state agency scrutiny during the planning process or the development review process. Land uses are also tracked by the Coastal Commission during periodic reviews that provide additional data that are not available for inland portions of the upper Santa Rosa Creek watershed.

The geographic dividing line of the Santa Lucia Mountain ridge separates the development patterns in the upper Santa Rosa Creek watershed from other areas within the Adelaida Planning Area. While the majority of the planning area spreads east and south from the ridge to include land adjacent to the urban communities of Paso Robles, Templeton, Atascadero, Cayucos, and Morro Bay, the upper Santa Rosa Creek watershed is remote from urban communities other than Cambria and is connected to Cambria only by Santa Rosa Creek Road which at some points narrows to a single lane. Santa Rosa Creek Road is the only collector road in the watershed (Adelaida Planning area Circulation Map). Therefore, data representing the overall Adelaida Planning Area do not reflect the coastal influences, geographic conditions and development patterns that have occurred in the upper Santa Rosa Creek watershed and cannot be relied upon to show development trends in that area. The development projects completed between 2003 and 2008 in the Adelaida Planning Area (Table 2-1) do not represent the development that has occurred on the upper slopes of the Santa Rosa Creek watershed. For example, there are only two wineries in the Santa Rosa Creek watershed, while data for the Adelaida Planning Area show 36 new wineries completed between 2003 and 2008 (Table 2-1).

Development on the majority of privately-owned currently undeveloped parcels in the watershed is limited under Williamson Act contracts (Figure 2-4). The Williamson Act, the common name for the California Land Conservation Act of 1965, enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments which are much lower than normal because they are based upon farming and open space uses as opposed to full market value. If Williamson Act contracts are allowed to expire one of the primary land use controls in the watershed will be lifted, and large parcels, particularly in the Adelaida Planning Area where California Coastal Act and Local Coastal Program protections do not apply, may be at risk of subdivision and development.

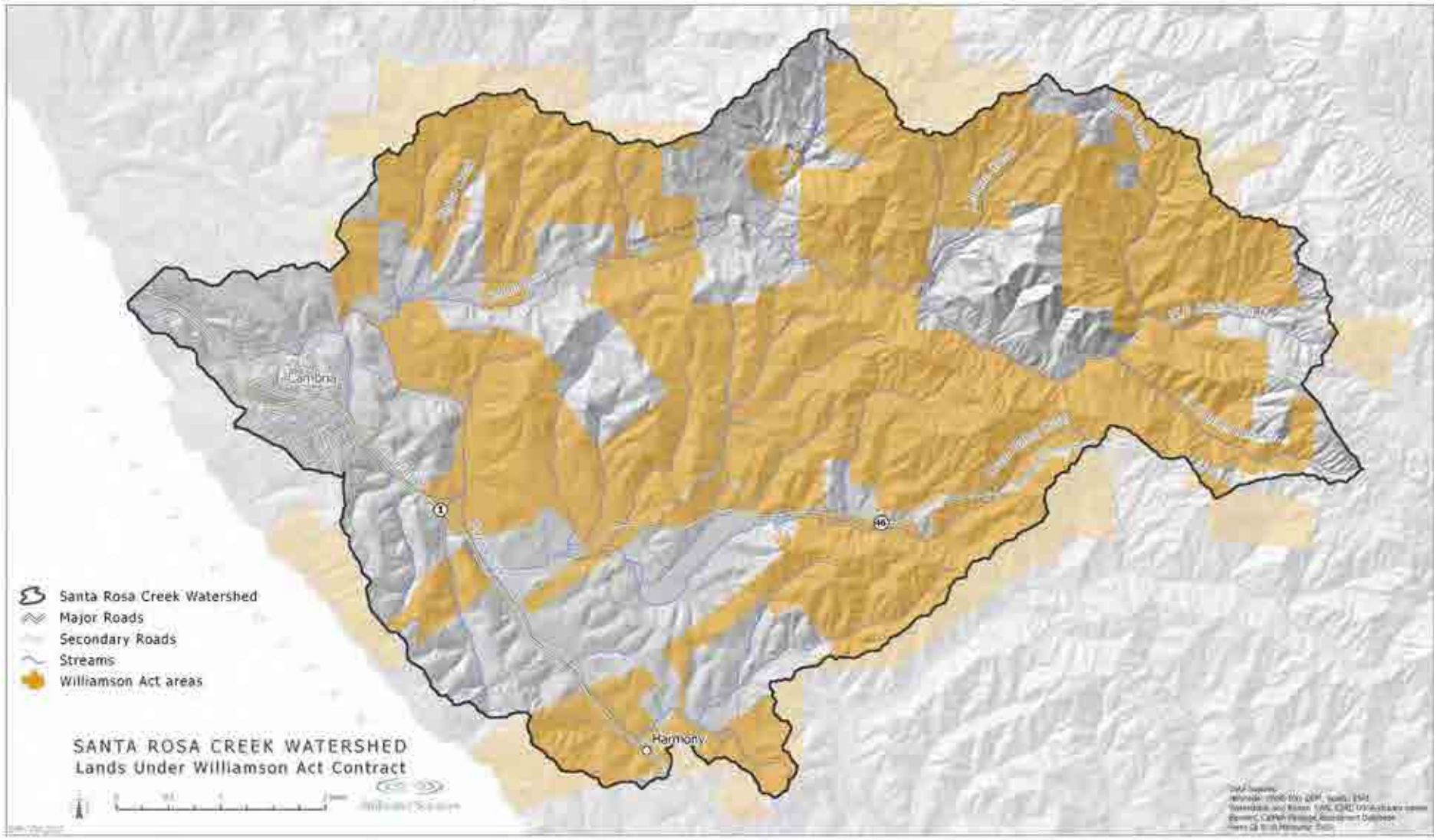

Figure 2-4. Land under Williamson Act contract within the Santa Rosa Creek watershed.

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The CCSD and U.S. Army Corp of Engineers (USACE) are currently assessing the feasibility of a seawater desalination plant at the mouth of Santa Rosa Creek. The desalination plant would improve water supply reliability in the CCSD service area, particularly in dry years, by augmenting the San Simeon and Santa Rosa Creek groundwater aquifers that are currently relied upon (CCSD 2008). At the December 9, 2011 California Coastal Commission hearing the USACE was unanimously denied a Coastal Consistency Determination by the Commission to conduct geo-technical drilling in the vicinity of the mean high tide line at the mouth of Santa Rosa Creek. The Commission determined that the proposed geo-technical study site was inappropriate because the mouth of Santa Rosa Creek and the associated lagoon are among the most protected and sensitive habitats on the Central Coast. If ultimately approved, however, a desalination plant could remove one of the key physical controls on population growth in the watershed and surrounding areas. The proposed desalination plant has the potential to produce unlimited amounts of water; however, as currently proposed it would produce 602 acre-feet of water per year. The plant would consist of subterranean seawater intake, pumping and pipeline facilities to transport the seawater to the desalination plant, reverse osmosis desalination treatment, a groundwater blending system, facilities to pump the treated water into the water supply distribution system, and disposal of desalination effluent into the ocean. The site currently being considered for intake and effluent disposal is the beach at the mouth of Santa Rosa Creek (CCSD 2008). Potential impacts related to construction and operation include: disturbance and mobilization of mercury, adverse impacts to protected species such as steelhead, California red-legged frog, and tidewater goby (California Coastal Commission 2010), and drawdown of water levels in the lagoon. To avoid influencing lagoon water levels, the beach wells must be constructed more than 500 feet from both the Santa Rosa and San Simeon creek lagoons (North Coast Engineering, Inc. 1993).

The growth-inducing impacts of a future water supply project such as a desalination plant and the additional water supply it will create, were analyzed in CCSD's Water Master Plan program-level Environmental Impact Report, which was certified by the CCSD Board of Directors on August 21, 2008 (R. Gresens, pers. comm., 2012). The CCSD operates a voluntary Buildout Reduction Program inside the town of Cambria, designed to reduce water demand by retiring and merging buildable lots. In addition, CCSD must also abide by conditions in San Luis Obispo County's (2008) North Coast Area Plan, which states that for any major public works water supply project to support new development within the CCSD service area "[t]he maximum service capacity of the project will not induce growth inconsistent with the protection of coastal resources and public access and recreation opportunities" and that "[t]he project shall assure that CCSD water withdrawals from Santa Rosa and San Simeon Creeks will be sufficiently limited to protect: (1) adequate instream flows necessary to support sensitive species and other riparian/wetland habitats within the reach of the streams affected by CCSD pumping; (2) underlying groundwater aquifers; and (3) agricultural resources." The North Coast Area Plan, however, anticipates that desalination will be a source of water for development outside of Cambria and, as such, the potential for growth-inducing impacts associated with a desalination plant or other major water supply project would primarily be outside of the current CCSD service area. By ordinance, CCSD accepts and processes applications for delivery of water outside of Cambria based on availability of water, which would notably increase if a desalination plant or other major water supply project becomes operational. In 2006, Measure P-06 was passed by CCSD-district voters which requires a majority vote of the CCSD electorate to extend potable water service outside of 2006 CCSD boundaries. Measure P-06 further requires an environmental review under the California Environmental Quality Act and an amendment to the Water Master Plan before potable water service is extended beyond 2006 CCSD boundaries.

2.3 Climate

Coastal watersheds along the western flank of the Coast Ranges experience a two-season Mediterranean-type climate, with wet cool winters and dry warm summers. The regional climate is controlled by the North Pacific High, a high pressure system resting over cold upwelling waters of the eastern Pacific, while the local climate is controlled by the watershed's topography and proximity to the ocean (Carle 2006). The Pacific High system deflects storms from reaching the California coast during summer months, resulting in dry westerly winds blowing over cold ocean water and often producing fog. In the Santa Rosa Creek watershed, this fog belt typically extends inland 8 miles from Cambria. During winter, the Pacific High retreats to the south resulting in high rainfall in California concentrated between November and April. Overall, the California coast experiences highly variable annual rainfall depending on each storm's frequency and magnitude on the landscape relief. Mean annual rainfall across the watershed varies between 21 and 37 in (53 and 94 cm), as reported by the U.S. Department of Agriculture (1971–2000) and San Luis Obispo County Division of Public Works (1954–2008) (Figure 2-5). A clear pattern of increased rainfall with elevation is expressed across the watershed, as the lowlands near Cambria, including much of Perry and Green Valley creeks, receive nearly half the rainfall received in the headwaters of Santa Rosa Creek.

Periodicity in the pattern of the wet/dry years in California is correlated to the El Niño–Southern Oscillation (ENSO) climatic phenomenon. ENSO is characterized by warming and cooling cycles (oscillations) in the waters of the eastern equatorial Pacific Ocean. Specifically, El Niño episodes are initially driven by abnormally low atmospheric pressures in the eastern Pacific, resulting in lower upwelling rates of cold ocean waters and, therefore, a persistence of warmer surface water temperatures (Kousky and Bell 2000). Ultimately, the warmer waters lead to increased precipitation along the eastern Pacific, extending up to California. ENSO cycles typically have a 1- to 1.5-year duration and 3- to 8-year recurrence interval. ENSO-induced climate change occurs on a multi-decadal time scale that is consistent with the recent shift from a relatively drier climate (averaged over the period 1944–1968) to a relatively wetter climate (averaged over the period 1969–1995) in North American's Pacific region (Inman and Jenkins 1999). The most recent El Niño events occurred in water years 2007 and 2010 (NOAA 2009a).

A long-term record of annual precipitation totals in San Luis Obispo County (SLO Cal Poly rain gauge #1.0) from 1870 to present day is presented in Figure 2-5. The precipitation record indicates periods of cumulative wetter and drier periods in the region, where most wet years coincide with large floods (see Section 2.6).

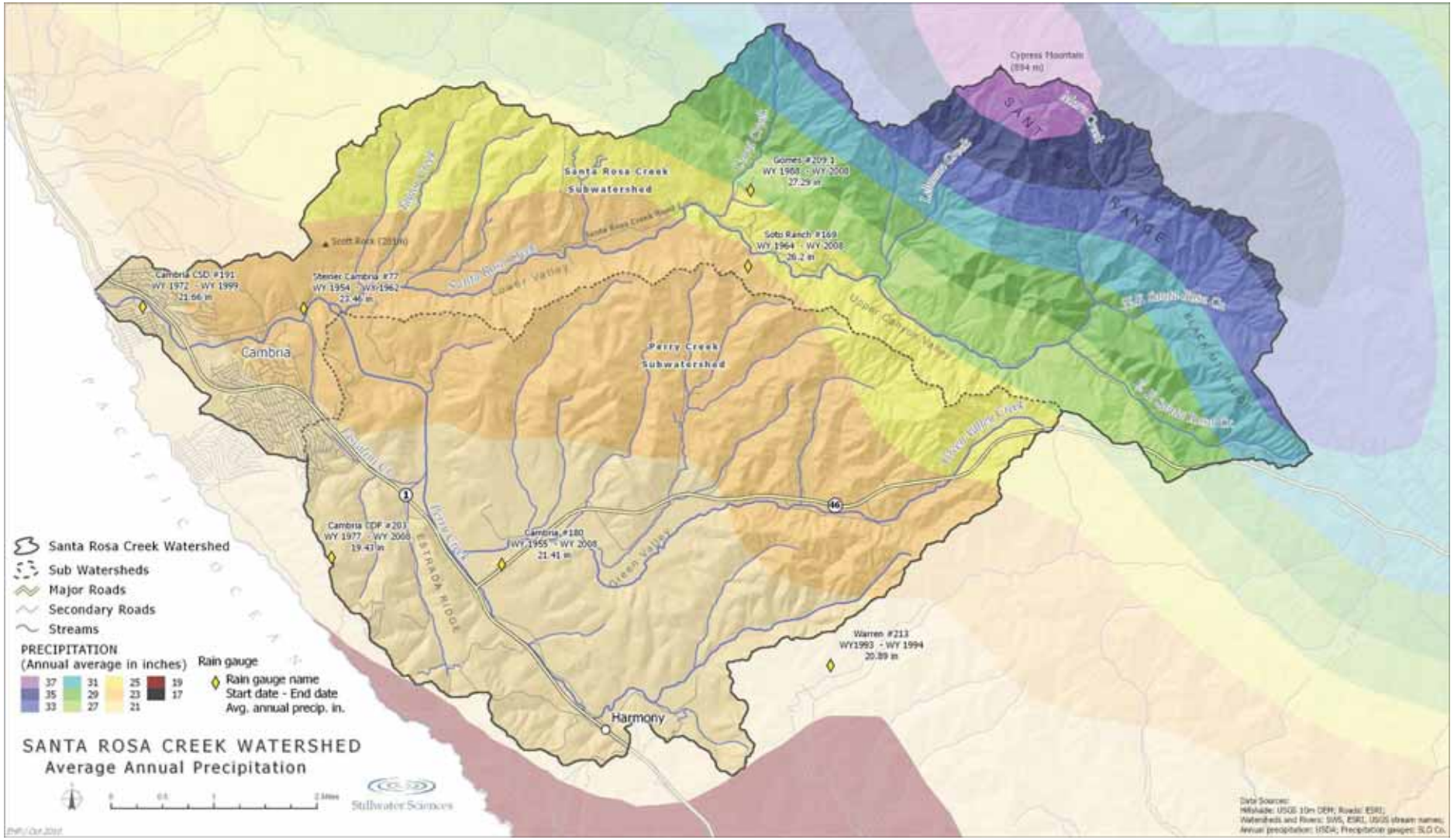

Figure 2-5. Distribution of average annual precipitation in the Santa Rosa Creek watershed. Precipitation contours represent the period of 1960–2001. Rain gauge stations representing various years of data shown for reference.

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In the future, the Santa Rosa Creek watershed is likely to be affected by changes in temperature, precipitation, and sea-level resulting from global warming. Predictions of climate change in California in the next century include warmer winters (by 5–6° F), slightly warmer summers (by 1–2° F), and increased winter precipitation (primarily as rain rather than snow), particularly in the mountains (Field et al. 1999). ENSO events may increase in intensity and/or frequency (Field et al. 1999). In central and southern California the change in precipitation timing is expected to lead to increased winter runoff, decreased summer stream flow, and changes in the frequency and/or intensity of severe storms, droughts, wildfires, and flooding. In addition, global climate change is expected to result in sea-level rise. Based on a set of climate scenarios prepared for the California Energy Commission, Cayan et al. (2009) project that, under medium to medium-high greenhouse gas emissions scenarios, mean sea level along the California coast will rise from 3–5 ft (1–1.4 m) by the year 2100. In the Santa Rosa Creek watershed, such a rise in sea-level would put new areas at risk of flooding, increase the likelihood and intensity of floods in areas that are already at risk, and accelerate shoreline recession due to erosion (Figure 2-6) (Heberger et al. 2009). Such predictions stress the importance of floodplain and coastal conservation, ecosystem restoration, and water conservation to increase the adaptability and resiliency of the watershed to respond to these changes, particularly when considered in conjunction with future land uses and human impacts to the watershed.

Figure 2-6. Predicted flood risk in 2100 in the Cambria area under a 1.4-m sea-level rise scenario. Light blue area is the current coastal base flood (approximate 100-year flood extent), dark blue area is the predicted coastal base flood under sea-level rise (current plus 1.4 m), yellow line is the predicted landward limit of erosion high hazard zone in 2100, and red line is Highway 1. Map used with permission from the Pacific Institute, Oakland, California.

2.4 Geology, Tectonics, and Soils

The Santa Rosa Creek watershed lies along the Santa Lucia Mountain range near the southern end of the geologically distinctive Coast Range geomorphic province. Orientated with the overall NW-SE trending grain of the California topography, the Santa Lucia range follows the southern Coast Range for 93 mi (150 km) between Monterey Bay to the north and the San Rafael Mountains to the south near Santa Barbara. The province resides within a tectonically active zone composed primarily of right-lateral strike-slip (horizontal sliding motion) faults separating the Pacific and North American plates. At the axis of this zone is the 600-mile-long (1,000-km-long) San Andreas Fault, which lies 37 mi (60 km) to the east of the Santa Rosa Creek watershed. Overall, this tectonically and geomorphically active province exhibits intermittent seismicity and asymmetrical drainages offset by faulting. Additionally, the presence of relatively weak rocks at higher elevations in the Santa Rosa Creek watershed has led to naturally high sediment delivery rates, or sediment yields, from those higher relief and steeper tributaries (see Section 2.5).

Much of the Coast Range province, and especially the Santa Rosa Creek watershed, is composed of old, weathered, and partially metamorphosed sedimentary rocks originally formed during the Mesozoic (200 to 100 million years ago [Ma]) and Cenozoic (65 to 25 Ma) eras (Chipping 1987). Today, the majority of the Santa Rosa Creek watershed is predominately (~50%) composed of Franciscan mélange: a mix of hard graywacke (sandstone) and weak, sheared argillite (silt/claystone) (Chipping 1987, Dibblee 2007a 2007b) (Figure 2-7). Following the complete subduction of the Farallon Plate beneath the North American Plate, the eventual transition to a transform (strike-slip) plate boundary began about 25 Ma with the gradual contact between the northwest-moving Pacific Plate and the southeast-moving North American Plate (Atwater and Molnar 1973). This transition marked a geologically brief period of coastal volcanism which locally produced the erosion-resistant Cambria Felsite rocks, as seen today at Scott Rock located east of Cambria near Taylor Creek (Dibblee 2007a). Other volcanic rocks formed during this period include the now highly weathered basalts and hardened tuffs (solidified volcanic ash) of the Obispo Formation that run along a northwest-trending band in the upper watershed. Terrestrial and marine sedimentary rocks formed during this period include a mix of hard, coarse-grained sandstones and weak, fine-grained shales.

The Coast Range orogeny, or mountain-building process, began during the late Pliocene and Pleistocene epochs ($\leq$4 Ma) and continues today. Regional uplift has been driven by crustal convergence that occurs where subtle NW–SE trending bends along the active transform fault zones forcing materials in between the larger faults to “pile up,” thereby creating the upland areas of the watershed. Obvious evidence of geologically recent uplift activity is the existence of Pleistocene marine terraces situated along the coastline and the lower watershed. Tectonic movement here may explain the watershed’s unusual drainage pattern of being split in two primary halves—Santa Rosa Creek and Perry Creek sub-watersheds—where Perry and Green Valley creeks may have once flowed directly to the coast but were eventually “captured” by Santa Rosa Creek as uplift and transverse migration of the elevated landscape re-directed Perry and Green Valley creeks northward. Coincident with the Coast Range uplift period, the valley floors along Santa Rosa, Perry, and Green Valley creeks have accumulated unconsolidated alluvial and stream-terrace deposits as the uplifted landscape has eroded and delivered its sediments to the valley floors over time. It is within these sediments that the watershed’s groundwater basin has developed, which currently serve as a primary water supply source to urban areas and land use activities in the watershed (see Section 2-6).

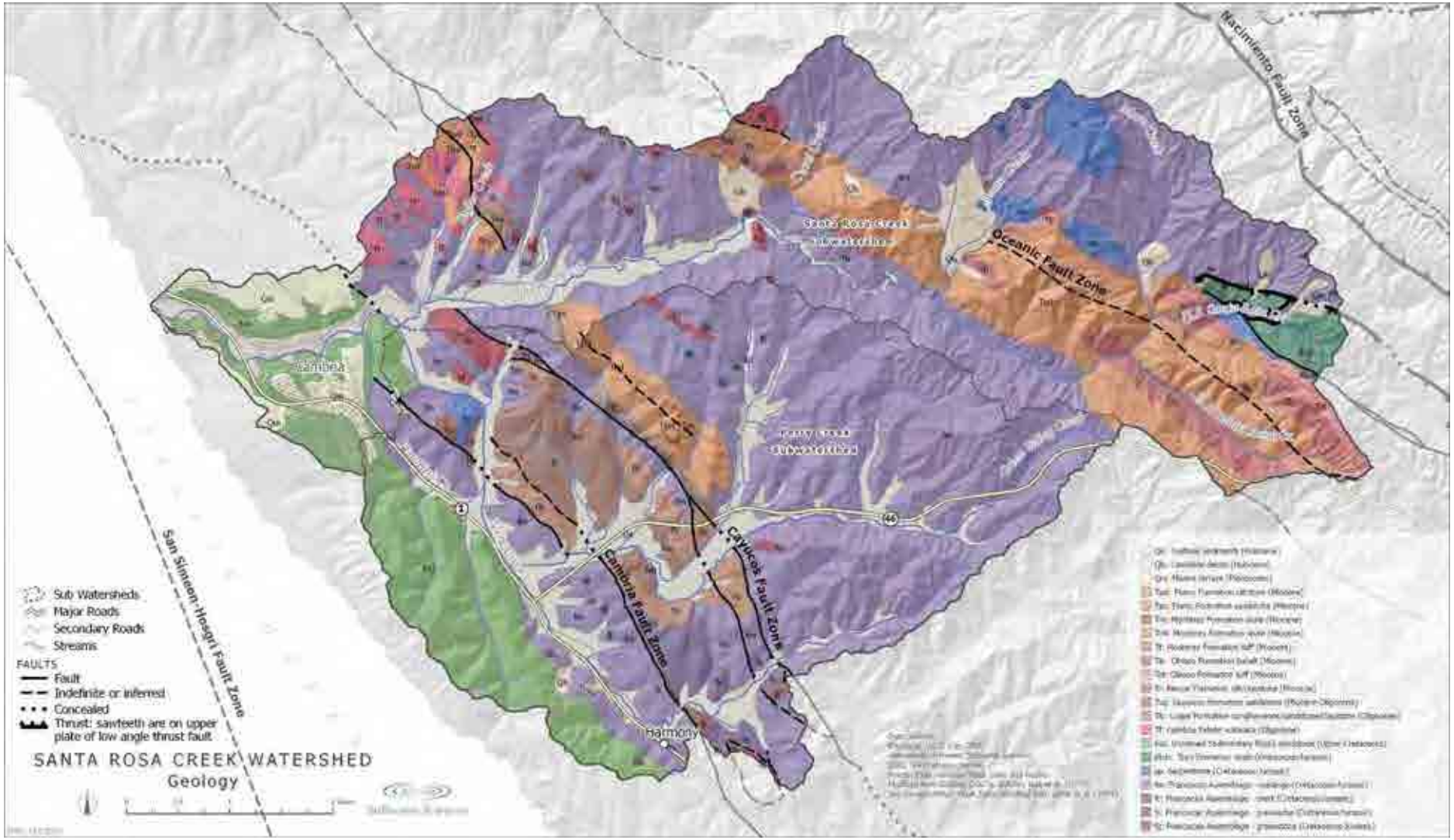

Figure 2-7. Santa Rosa Creek watershed geology.

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With continuous landscape uplift to drive hillslope processes and large areas of highly sheared metamorphic and sedimentary rock units now hundreds of meters above the valley bottoms, the Santa Rosa Creek watershed has geologic characteristics commonly associated with high rates of erosion. Field observations indicate that areas in the watershed displaying relatively high hillslope erosion are chiefly underlain by the fine-grained and easily eroded siltstone and mudstone of the Pismo (shale member), Monterey, Rincon, and Toro formations found traversing the watershed close to the two primary fault traces, and the highly fractured graywacke/argillite of the Franciscan mélange unit that is found throughout the watershed (Figure 2-7).

The sedimentary, metamorphic, and volcanic rocks of the Santa Rosa Creek watershed provide the parent material for much of the watershed's soils, and are one of the primary controls on soil texture and mineral content. As such, topographic form, rainfall runoff patterns, groundwater percolation rates, potential for erosion, and vegetation distribution are strongly influenced by geology. For this reason watershed geology, rather than soils, were used as the basis of the assessment of watershed geomorphology and hillslope sediment production estimates (see Section 2.5 for further discussion). Over 60 different soil types occur in the watershed, most of which are clay to sandy loams (NRCS 1977 and 1984). Additional details on watershed soils are summarized in TLCSLOC (2010).

2.5 Geomorphology

As all aquatic habitat is intimately linked to creek morphology and process, it follows that the habitat also responds to the flux created by sediment sources and storage sites within a watershed. They are particularly affected by changes away from "normal" conditions. For this reason, aquatic habitat is closely linked to geomorphic processes and the influence of human activity. The benefits and hazards of living near to a stream are also linked strongly to changing channel morphology and process: significant erosion of channel banks is often perceived as land loss by the owner, while sediment deposition raises channel bed elevations and makes the adjacent floodplain more prone to flooding. As such, understanding geomorphic processes and their alteration is also central to stream channel and watershed management in general.

A watershed-wide geomorphology study was conducted in 2009–2010 to provide information on the physical watershed and stream channel processes for the development of the watershed management plan. The study subdivided the lower 13 miles (22 km) of Santa Rosa Creek into upper, middle and lower reaches (Figure 2-8), which are referred to throughout this document[3]. The lower reaches begin at the river mouth (stream mile 0) and extend upstream to the confluence with Perry Creek (stream mile 3); the middle reaches extend from the Perry Creek confluence upstream to Mammoth Rock (stream mile 7); and the upper reaches extend from Mammoth Rock to stream mile 14. A detailed technical report of this study is presented in Appendix A, while the major findings have been summarized below.

From the chronology of watershed changes described in Section 2.1 and summarized in Figure 2-1, there are two time periods in recent history that likely had the greatest effect on watershed geomorphic processes: early land clearing in 1860–1880 and population growth, development, and road building from 1950–1990. Overall, the two periods both led to increased flashiness of streamflows, proportionally more rainfall entering the creek as runoff than from baseflow, and increased sediment entering stream channels, especially fine sediment. In comparison, it is likely that land clearing for lumber and agriculture created more extensive geomorphic impacts,

[3] D.W. Alley & Associates (2008) and Nelson et al. (2009) both used different reach delineations for their steelhead monitoring and habitat typing. Reach delineation differences are described in more detail in Section 2.10.1.

including the majority of the over 1,000 gullies still evident across the watershed (see Figure 2-8), whereas the more recent impact of road and urban development primarily impacted Green Valley Creek and the lower reaches of Perry and Santa Rosa creeks.

2.5.1 Sediment production, transfer, and storage

Sediment refers to rock- and soil-derived material that ranges in size from clay to boulder, and includes cobble, gravel, and sand. Coarse sediment refers to gravel-sized material and larger (>2 mm in diameter) and overall has the greatest influence on the morphology of a stream channel (e.g., providing grade control, and forming bar-pool morphology). Fine sediment refers to clay-, silt-, and sand-sized materials (<2 mm in diameter), which in excess can have detrimental affects on aquatic habitat conditions. As a geomorphic unit, a watershed serves to transport sediment from its place of origin to an eventual place of lasting storage. In so doing, a distinctive relief is developed in the watershed that reflects the balance between long-term processes of tectonic uplift and rates of erosion driven by physical, chemical, and biological factors. This balance is generally achieved through the medium of moving water. Sediment sources are those sites predominantly characterized by erosion and often have steep slopes. Sediment storage, particularly in a small coastal watershed such as Santa Rosa Creek, occurs mostly offshore as sediment-laden water exits the watershed, but it also occurs where sediments are deposited on floodplains (where the material is termed alluvium) and at breaks to gentler hillslope gradients (termed colluvium). Connecting sediment sources with their sites of long-term storage is a flux of sediment transport through the watershed, typically occurring on a time scale from years to centuries. The flux of sediment is intermittent and driven mostly by large rainfall or streamflow events, and so most such “short-term” sediment transfer occurs along the creek channel. The exact locations of the short-term sources and storage sites of sediment can, however, be influenced as strongly by human activities as by natural factors. A typical short-term sediment source is the erosion of alluvial stream banks, representing the re-mobilization of previously stored sediment, while short-term sediment storage often occurs on the channel bed in the form of a wave of “excess” sediment deposited after a flood event. Therefore, the typical transfer of sediment through a watershed involves a flux in which changes to the creek morphology is an integral part.

Present day Santa Rosa Creek watershed is characterized, as are most other watersheds, by a wide variety of sediment sources that potentially affect management decisions. The predominant sediment sources and stores in the Santa Rosa Creek watershed, and the dynamics of sediment transfer, are summarized in Table 2-2 and the various source locations mapped in Figure 2-8 (additional detail is also available in Appendix A). The very steep hillslopes in the headwaters of Santa Rosa Creek (and some tributaries to Green Valley Creek) have naturally high sediment yields, and it seems likely that, in geomorphic terms, the historically-noted steelhead populations in the watershed result in part from the habitat created by the delivery of very coarse sediment from the upper reaches of Santa Rosa Creek. The other predominant sediment sources in the watershed have resulted primarily from previous land and channel management, and include gullying, stream bank erosion, and road-related erosion. These processes primarily involve the erosion of the landscape’s soils and thus supply primarily only fine sediment to watershed channels.

Historical land clearing for lumber and agriculture is likely responsible for the majority of the over 1,000 gullies still evident across the watershed (Table 2-2, Figure 2-8). Fine sediment yields from these features most likely increased substantially during and following land clearing in the late 1800s and early 1900s, but have probably been reduced closer to historical levels in recent decades (see “Fine Sediment Delivery” in Figure 2-1). This is because, with the exception of

development in Cambria over the past several decades, land uses across the vast majority of the watershed have not changed considerably over the past half-century (see Section 2.1). Outside of Cambria's urban boundaries, contemporary views of the landscape are very similar to historical views from the early 1900s, and the number and location of gullies have not noticeably changed since 1937 (see Appendix A for additional detail). Streambank erosion in Santa Rosa Creek is exacerbated by channel incision, a deepening of the channel often resulting from perturbations to the watershed. Channel incision is assumed to have occurred quickly after initial land clearing activities began in the mid-19th century. Over time, channel incision eventually causes the mass instability of channel banks, which then become a source of fine sediment. More recently, channel meandering in the incised reaches has resulted in the erosion of high alluvial banks of the former floodplain (Figure 2-8). Over 250 instances of recorded road-related erosion features exist in the watershed (Figure 2-8), which effectively deliver predominately fine sediment to the channel network. Erosion is focused along cut and fill sections of Highway 46 and Santa Rosa Creek Road, and to a lesser extent Highway 1.

Coarse sediment (gravel and larger) delivered to the mainstem Santa Rosa Creek appears to be delivered primarily from Lehman and Curti creeks in the upper reaches, and from the tributary that runs adjacent to Main Street in the lower reach. Fine sediment (sand and silt) appears to be predominantly derived from tributary sources such as Curti Creek and Perry Creek, which delivers sediment to the lower reach, and local in-channel sources such as bank erosion in the middle reaches.

Table 2-2. Sediment sources, storage, and transfer dynamics in the Santa Rosa Creek watershed.

Location	Process/Description
Sediment Sources	
Landslides	Only 17 landslides are recorded in the areas of watershed without canopy cover, but they are individually high-yielding. Landslides are concentrated in high relief, steep-sided areas, primarily in the headwaters of Santa Rosa Creek. Landslides erode previously stored colluvium on hillslope swales and, potentially, weathered bedrock closer to the failure plane. Mixed-load sediments released as part of large deep-seated landslides, as mapped in geologic maps of the watershed (see Figure 2-7), may reside for years to centuries before eventually being completely delivered to the stream network.
Gullies and rills	Gullies and rills are numerous throughout the watershed. Over 1,000 gullies have been recorded and many have evidently been present since the late 19th century and so may be past their sediment production peak. These features primarily result in the production of fine sediments as they erode soil-mantled, moderately steep hillslopes and, because they are often connected directly to the stream network, a near 100% delivery ratio of sediment can be inferred. Gullying in the watershed is likely to have resulted in far higher volumes of fine sediment delivered to the channel network during and following their formation, which have likely been reduced closer to pre-development levels in recent decades.
High yielding Geomorphic Landscape Units	Areas of the watershed with the highest sediment yield potential are primarily situated on steep, grassland and barren hillslopes composed of weak rock. These areas result in the production of both coarse and fine sediments, but fine sediments are probably derived preferentially from the widespread Franciscan mélange terrain. Sediment delivery from these Geomorphic Landscape Units (GLUs) (see Figure 2-8 and Appendix A) is likely high given the steep hillslopes and confined and steep channels.
Creek incision	Channel incision in the major streams is assumed to have occurred quickly after initial land clearing activities began in the mid-19th century. Incision is widespread but focused in the middle reaches[c] of Santa Rosa Creek and the middle and upper reaches of Perry and Green Valley creeks. Incision initially releases channel bed sediments which may be relatively coarse.

Location	Process/Description
Bank erosion of high bluffs following incision	Over time, channel incision eventually causes the mass instability of channel banks of the former floodplain which then makes them a highly effective source of finer sediment as the channel widens. More recently, meander activity as the incised reaches recover their equilibrium has allowed erosion of high alluvial banks of the former floodplain, causing a net sediment supply biased towards fine sediment.
Road-related erosion	Over 250 instances of recorded road-related erosion features exist in the watershed. Erosion is focused along cut and fill sections of Highway 46 and Santa Rosa Creek Road (and to a lesser extent Highway 1). Because road drainage frequently serves channel road runoff from the road surface efficiently to the channel network, sediment (particularly fine sediment) is also delivered very effectively to the channel network.
Sediment Storage	
Lower Perry Creek in the vicinity of the former Estrada Lake	Historically, Estrada Lake at the downstream end of Perry Creek probably trapped all coarse and most fine sediments delivered by the contributing streams, meaning that few sediments from the Perry Creek sub-watershed ever reached Santa Rosa Creek. Subsequent draining of the lake to create a trapezoidal channel permitted the transport of sediment, especially fine sediment, from the Perry Creek sub-watershed into Santa Rosa Creek. Subsequent incision of the lowest reach of Perry Creek must have resulted in the remobilization of former lake sediment (i.e., fine, organic-rich sediment). The broad-bedded, low gradient ditch farther upstream still favors the deposition of coarse sediments before reaching Santa Rosa Creek, and a noticeable fining of bed material occurs on Santa Rosa Creek downstream of the Perry Creek confluence.
Water storage ponds	There are over 40 small water storage ponds throughout the watershed, with a greater proportion in the Perry Creek sub-watershed (Figure 2-8). They regulate 8% of the watershed area but are likely to have low sediment-trapping efficiencies, trapping primarily a small amount of coarser-grained sediments.
Channel bed in upper reaches	Field evidence indicates temporary storage of coarse sediments delivered from the steep, high relief tributary sub-watersheds (e.g., East Fork Santa Rosa and Curti creeks) into mainstem Santa Rosa Creek. Along the mainstem, there is also field evidence for the temporary storage of coarse material in channel and floodplain locations. Remobilization of the coarse sediment occurs during high flow events with material either wholly entrained or abraded into finer, more easily-transportable particles.
Channel bed in lower reaches	While lower gradient reaches are frequently characterized by finer sediment beds and sediment deposition, field evidence of short-term storage of fine material on the channel bed may reflect high rates of fine sediment supply to the lower reaches, especially from the Perry Creek sub-watershed.
Transfer Dynamics [a]	
Upper reaches	The upper reaches are very capable of mobilizing the median grain size (~2–3 in [~50–90 mm]) of the channel bed during even moderate flow events and the channel morphology rates as highly active. Fine sediment is transferred quickly from the reaches, whereas field evidence indicates the temporary storage and probable breakdown of very coarse material.
Middle reaches	Middle reaches are competent to transport the median grain size (~0.7–2 in [~20–50 mm]) of the channel bed during even moderate flow events and the channel morphology rates as highly. This stream power is borne out by increased sinuosity in these reaches since the early 20th century in which coarse sediment is deposited in the form of channel bars and larger volumes of fine sediment are derived from the high banks of the former floodplain surface.
Lower reaches	Lower reaches are competent to transport the median grain size (~0.2–1 in [~5–45 mm]) of the channel bed during even moderate flow events and the channel morphology rates as highly active. These reaches exhibit unusually high stream power for such low gradient reaches and may reflect bank protection which prevents the exchange of sediment from channel banks and prevents channel widening in response to flood events.

[a] See Figure 2-8 for locations of Santa Rosa Creek reaches.

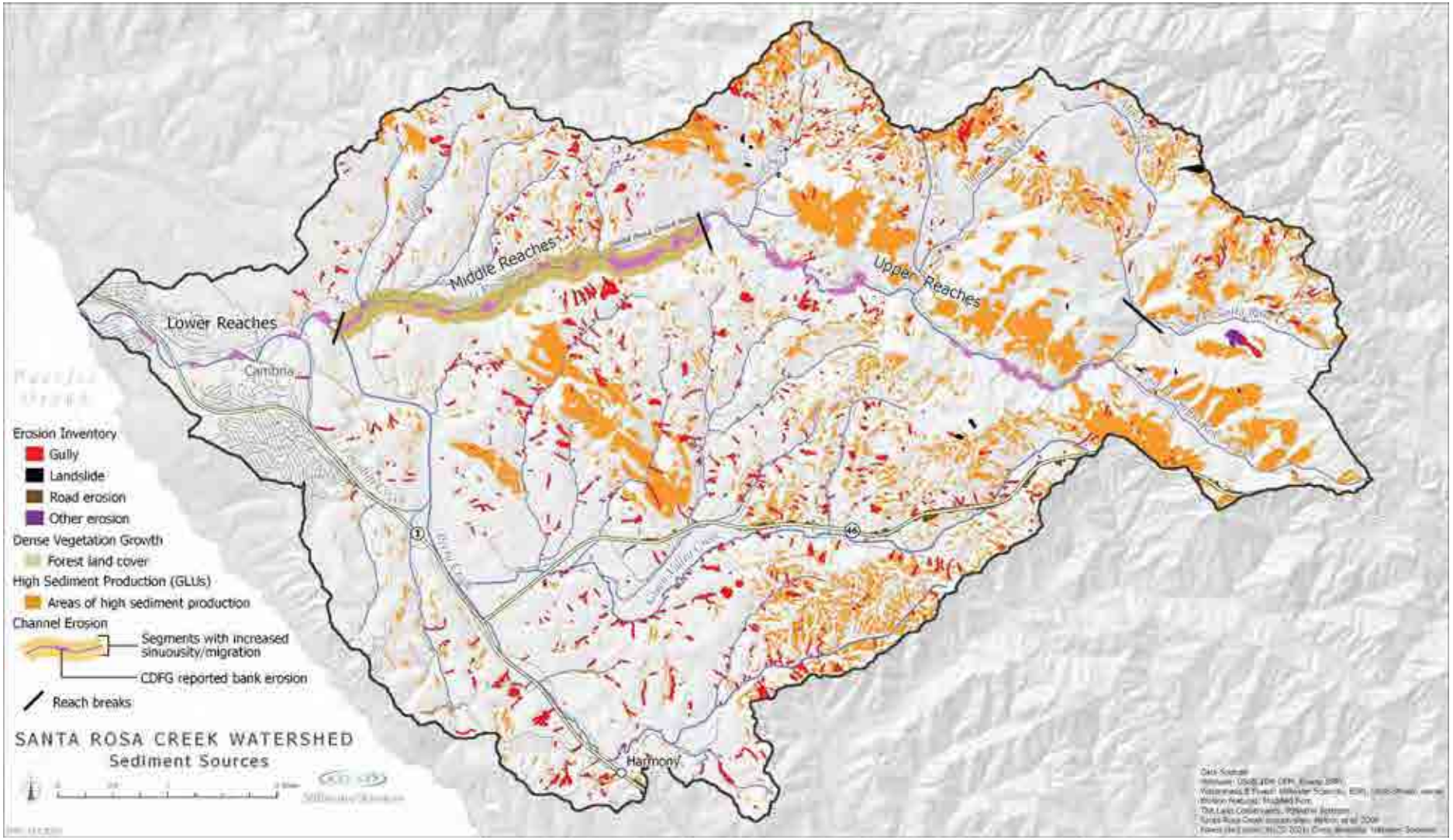

Figure 2-8. Sediment source and transfer areas in the Santa Rosa Creek watershed.

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2.5.2 Channel morphology

Understanding the character of the creek morphology and its sediment is a fundamental component in understanding how fluvial processes will affect the creek, the likely extent and availability of aquatic habitat, the extent of human impacts on the creek, and should be used to devise appropriate management actions into the future. Conditions in the upper, middle and lower reaches of Santa Rosa Creek, the Perry/Green Valley Creek sub-watershed, and lagoon are summarized below.

The upper reaches of Santa Rosa Creek are characteristic of a mountain river, with a steep, confined morphology and a boulder-cobble-gravel bed. Lehman and Curti creeks provide a relatively high supply of coarse to fine sediment to these reaches.

The middle reaches display the features of a classic alluvial channel, with a sinuous channel that meanders through deposited alluvium, and a cobble-gravel bed characterized by pool-riffle bedforms. The middle reaches transition from a highly incised reach with active bank erosion and high sediment input at its upstream extent, to a moderately incised and apparently less dynamic reach as the degree of channel confinement increases and bedrock control once again becomes an influence near the confluence with Perry Creek. Comparing aerial photographs from 1937 to 2007, there has been a significant increase in the sinuosity of the middle reaches (Figure 2-8). The increase in sinuosity of this incised reach is evidence that the channel is still recovering from the impact of land use change in the mid-19th century. Land clearing for lumber and agriculture changed rainfall-runoff dynamics by decreasing landscape surface roughness (i.e., vegetation removal), thereby increasing the stream power in the creek for a given rainfall intensity and duration (i.e., increased hydrograph "flashiness"). Stream bank erosion in the middle reaches is one of the primary sources of fine sediment in Santa Rosa Creek.

Examples of conditions in the upper, middle, and lower reaches of Santa Rosa Creek

Bedrock control returns at the junction with the lower reaches which have a sand-gravel bed and are moderately confined by terrain and development and show signs of aggradation before becoming tidally influenced near the low-gradient creek mouth (described in more detail below). Sediment delivered to the lower reaches from upstream Santa Rosa Creek, Perry Creek, and from local tributaries has resulted in a large amount of stored sediment in the reach. Banks are relatively stable, not least where extensive riprap protection exists.

Perry Creek enters Santa Rosa Creek approximately 2 mi (3 km) upstream of the Highway 1 Bridge and is the largest tributary. It is characterized by a moderately confined channel with finer bed sediment that flows approximately 10 mi (16 km) from the town of Harmony downstream to the confluence with Santa Rosa Creek. Lower Perry Creek was channelized from the former Estrada Lake and begins as a trapezoidal cut roughly paralleling Highway 1 while the lowest reach is incised into the organic-rich sediments of the former lake bed. The major tributary of Perry Creek is Green Valley Creek, which enters approximately 5 km upstream from Santa Rosa Creek confluence. Green Valley Creek originates in the steep, south-facing hillslopes along Highway 46, flows west through a confined alluvial valley, and enters Perry Creek in a broad alluvial zone near Highway 1. From limited field observation and available data, the upper reaches of mainstem Green Valley Creek appear somewhat similar to the upper reaches of Santa Rosa Creek in terms of valley confinement, but unlike Santa Rosa Creek, Green Valley develops a very wide alluvial valley through its middle and lower reaches. These reaches are highly incised and actively eroding their banks. Together, Green Valley and Perry creeks transport a mixed sediment load skewed toward finer sediment that includes silt/fine sand to fine cobbles, with the dominant sediment bed particle size ranging from coarse gravel in the upper reaches to fine gravel in the lower reaches. The Perry/Green Valley Creek sub-watershed is another of the primary sources of fine sediment in Santa Rosa Creek.

Perry/Green Valley Creek sub-watershed

The morphology of the coastal barrier lagoon at the mouth of Santa Rosa Creek is influenced by prevailing onshore currents and the effects of a rock island close offshore, by flows from Santa Rosa Creek, and by topographic constraints that are both geologic and a function of a landfill and riprap (at present-day Shamel Park). The upstream end of the lagoon is defined by the upstream extent of tidal influence, which is well below the Highway 1 Bridge. Overall, the lagoon responds largely to incoming streamflow including its pattern of seasonal breaching which is usually in response to overwash from ocean swells and to high flows from Santa Rosa Creek that overwhelm the capacity of the lagoon. The morphology of the lagoon has remained remarkably static since at least 1919, when the earliest USGS (1919) topographic maps and aerial photographs of the area are available (see Appendix A for additional detail). In a comparison of the lagoon over time, two main patterns are apparent: (1) the mouth has nearly always occupied its current position, on the north end of the beach adjacent to the marine terrace, with few exceptions (e.g., 1986); and (2) the amount of vegetation adjacent to the lower creek channel and lagoon has increased considerably since the earliest aerial photograph in 1937 (see Appendix A for additional details). It can be inferred from historical aerial photographs that neither net aggradation nor erosion has occurred during the past 70-plus years based on the following: (1) the lower stream channel and lagoon have maintained a relatively static position (i.e., no meandering or avulsions); and (2) the lower stream channel exhibits a similar, albeit transitory, bar and pool morphology. This has positive implications for the continued functionality of an ecologically-important lagoon.

2.6 Surface and Groundwater Hydrology

2.6.1 Hydrologic conditions

The climatic and hydrologic characteristics of the watershed produce a perennial flow regime along the majority of Santa Rosa Creek, while most tributaries, including Perry and Green Valley creeks, experience intermittent flows (Figure 2-9). Discharge has been measured over the past 50 years in both the upper (i.e., upstream of Mammoth Rock) and lower watershed (i.e., downstream of the Perry Creek confluence) by three gauges operating at different time periods (Table 2-3, Figure 2-9). During this time annual maximum flow has ranged by a factor of ~50 (60 to 3,350 cfs [1.7 to 95 $m^3 s^{-1}$]) in the upper watershed, and even more widely (<1 to <12,000 cfs [<0.03 to 340 $m^3 s^{-1}$]) in the lower watershed between water years (WY) 1962–1994, with the largest flow recorded at both locations occurring in WY 1969. The monthly streamflow patterns closely follow the seasonal precipitation patterns, where the highest flows occur in winter (Figure 2-10). In summer and fall, monthly average flows are often less than 5 cfs (0.14 $m^3 s^{-1}$), leaving many stream reaches dry, such as immediately downstream of Mammoth Rock where any surface water delivered from upstream reaches seeps down to the groundwater table (Figure 2-9).

The discussion of watershed hydrologic conditions in this section are informed by two stream gauges: one in the upper watershed (USGS 11142200) and one in the lower watershed at the Highway 1 Bridge crossing (SLO County Station 16). The active stream gauge at the Main Street Bridge crossing (SLO County Station 21) is not included because it was found to have large variations in reported annual maximum discharge, likely as a result of a lack of flow calibration. For consistency, this discussion focuses instead on the Highway 1 gauge in the lower watershed because it was used as part of a recent USGS groundwater recharge study conducted in the watershed (Yates and Van Konyenburg 1998).

Table 2-3. Stream gauges of Santa Rosa Creek.

Stream gauge ID	Stream gauge operator	Stream gauge location	Period of record (water years)
USGS 11142200	U.S. Geological Survey	0.4 mi (0.7 km) upstream of Curti Creek	1958–1972
SLO County Station 16	San Luis Obispo County Water Resources, Division of Public Works	Highway 1 Bridge	1976–1992
SLO County Station 21	San Luis Obispo County Water Resources, Division of Public Works	Main Street Bridge	1989–present

From the extended annual maximum flow data, the annual maximum discharge expected to be equaled or exceeded approximately once every 1.5 to 2 years (the statistical “bankfull” flow event) during this time period is approximately 760–1,100 cfs (21–30 $m^3 s^{-1}$) in the upper watershed and 1,800–2,700 cfs (50–78 $m^3 s^{-1}$) in the lower watershed. These “bankfull” flow events, which are geomorphically significant (see below), have the potential to occur in any month, but are more likely to occur in February or March (Figure 2-10).

Similar to other Coast Range watersheds, flood flows in Santa Rosa Creek typically increase, peak, and subside rapidly in response to high intensity rainfall. This hydrologic attribute is characteristic of a “flashy” hydrograph, whereby a rapid increase in discharge occurs over a

relatively short time period with a quickly developed peak discharge in relation to normal baseflow (Ward 1978). Since 1958, large flood events have occurred in 1967, 1969, 1973, 1978, 1986, 1993, 1995, and 2005, frequently (but not always) corresponding with ENSO years (NOAA 2009b), which is consistent with an understanding that ENSO years in the Coast Ranges, especially south of 35ºN (Cambria is at 35.6ºN), are characterized by relatively high rainfall intensities, with rivers and streams exhibiting higher annual peak flows than they do in non-ENSO years (Cayan et al. 1999, Andrews et al. 2004).

Inundated floodplain during high flows

The Santa Rosa Valley groundwater basin underlies the Santa Rosa, Green Valley, and Perry creek valleys and is approximately 4,480 ac (7 mi^2) in size (Figure 2-9) (CDWR 2004). The groundwater storage capacity of the basin has been estimated at 24,700 ac-ft, although the actual volume is unknown and likely fluctuates in response to seasonal variations in rainfall and groundwater extraction (Yates and Van Konyenburg 1998, CDWR 2004). Groundwater levels in the basin are typically highest during the wet season, decline during the dry season, and then recover to higher levels in the following wet season. The groundwater basin is recharged primarily from seepage of surface flows in Santa Rosa Creek and its tributaries, deep percolation of precipitation, and residential/agricultural return flows (Yates and Van Konyenburg 1998). During dry periods, flows in Santa Rosa Creek can be insufficient to recharge the basin, which can lead to seawater intrusion and water quality degradation (Yates and Van Konyenburg 1998). Since the 1950's there has been one temporary seawater intrusion event (in 1961), although there is not a good understanding of why this occurred (Yates and Van Konyenburg 1998).

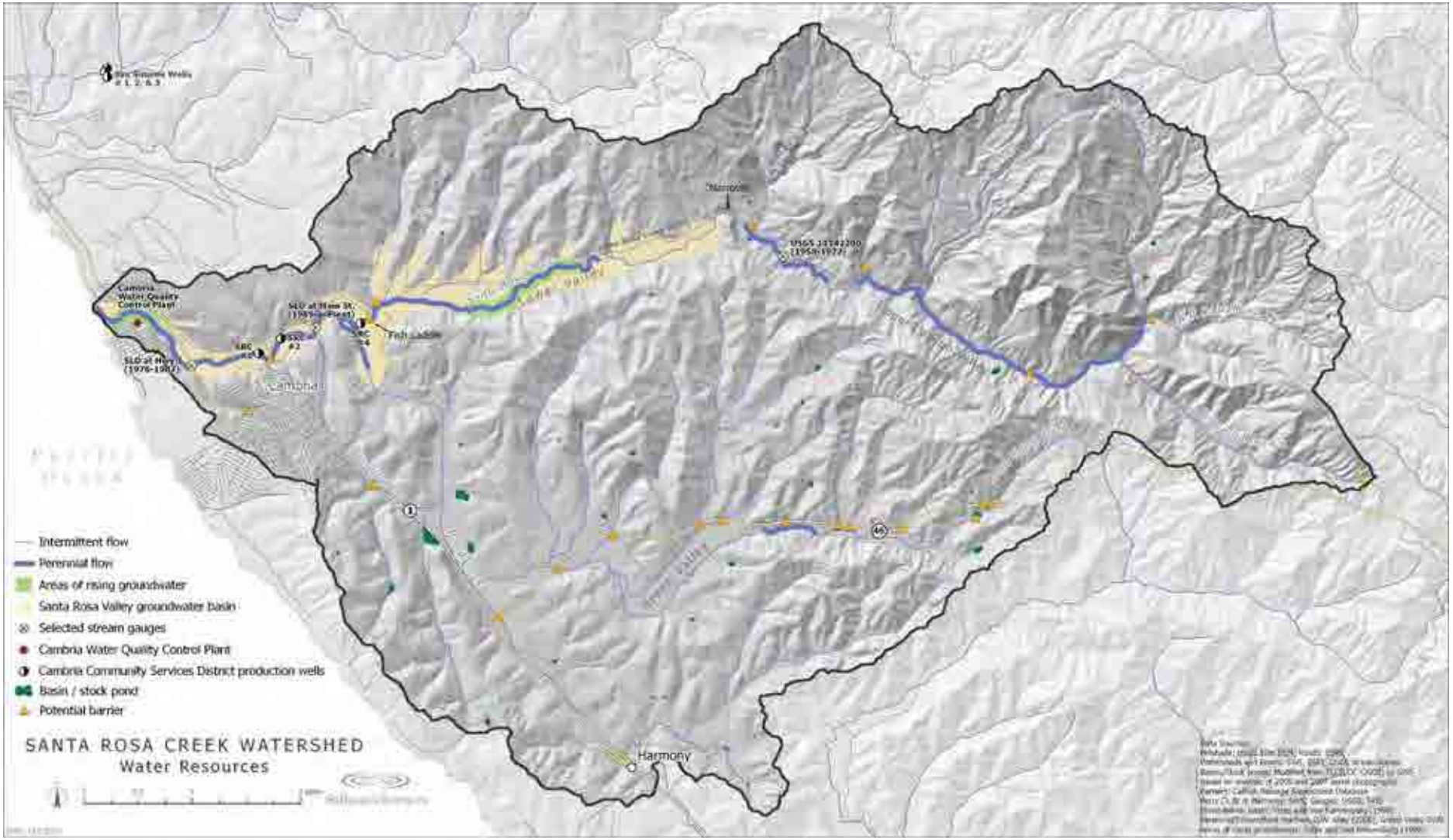

Figure 2-9. Water resources in the Santa Rosa Creek watershed. Perennial and intermittent streams, groundwater basin, and stream gauge locations are shown.

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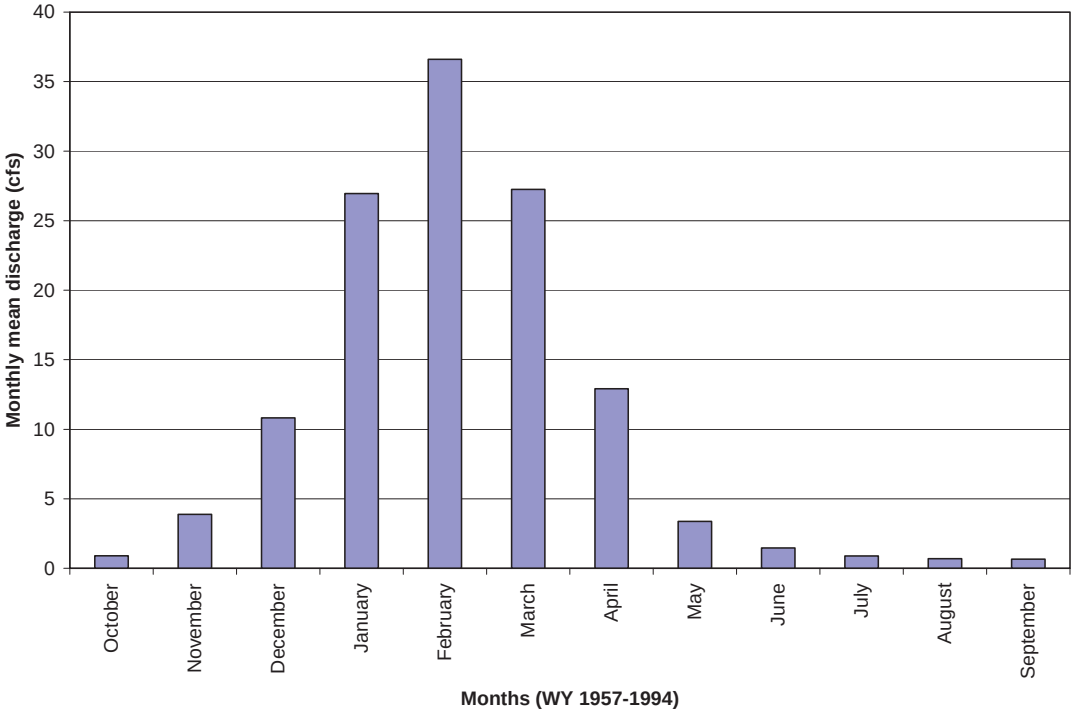

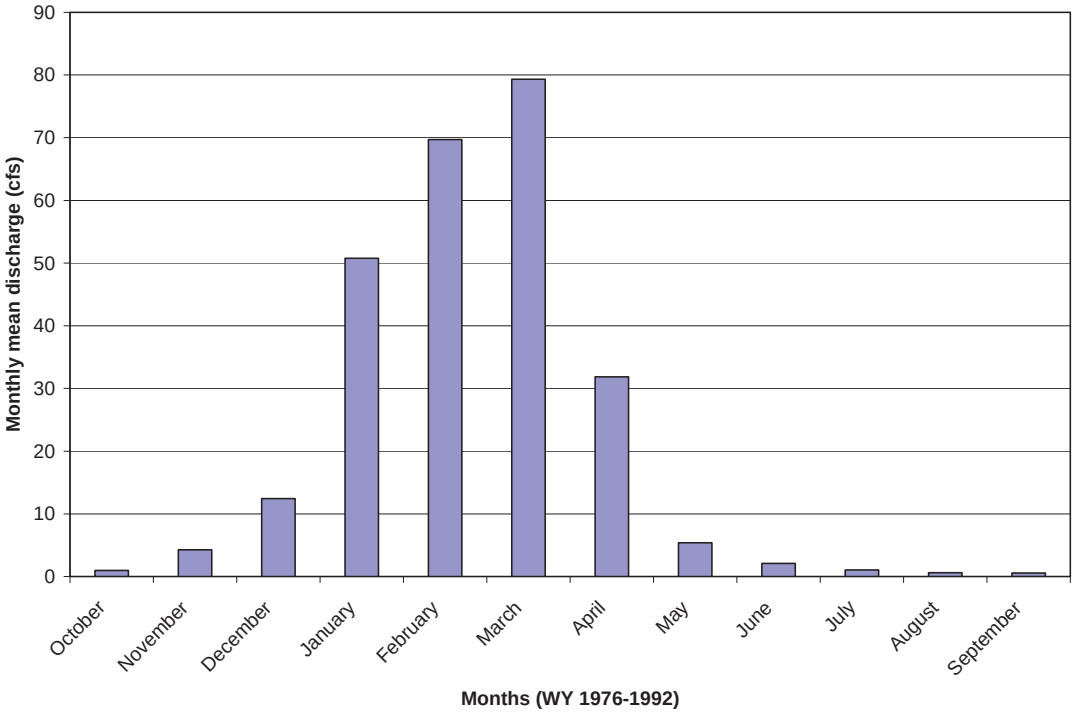

Figure 2-10. Monthly mean discharge for Santa Rosa Creek at Cambria based on USGS gauge 11142200 (from correlation with USGS gauge 11147070 to extend period beyond WY 1972 through 1994) (top) and SLO County Station 16 (bottom).

2.6.2 Groundwater extraction and surface water diversion

The urbanization time period between 1960 and the 1990s also represents an expansion of water use, primarily through groundwater pumping, to irrigate crops and provide drinking water to Cambria. The likely impact of groundwater extraction and limited surface water diversion has been an overall reduction in baseflow within Santa Rosa Creek, and potentially within Perry and Green Valley creeks. Until the San Simeon well field was established in 1979 (see Figure 2-9) to supplement municipal water demands in Cambria, the peak of groundwater extraction by CCSD for municipal water use in the Santa Rosa Creek watershed occurred in 1976 and totaled 520 acre-feet (CCSD 2009), or 3.6 times the total annual stream flow measured at the Highway 1 Bridge stream gauge (annual flow in 1976 = 144 acre-feet; 1976 was a dry water year) (Figure 2-11). Since 1979, annual extraction rates from the Santa Rosa wells have been strongly dependent on water year conditions, where rates peaked above 200 acre-feet during drought (or near-drought) years—1987, 1988, 1990, and 2008—and dropped close to zero during wet (or near-wet) years—1980, 1981, 1982, 1993, 1995, 1996, and 1998. Overall, extraction from the groundwater basin by CCSD has not exceeded the annual permitted limit of 518 acre-feet (CCSD 2008). In late 1990s, CCSD shut down its Santa Rosa wells (SRC-1 and SRC-2; see Figure 2-9) due to contamination risks from hydrocarbons from nearby leaking fuel tanks in Cambria. CCSD subsequently installed a new well (SRC-4) up-gradient of the fuel leak plume close to Coast Union High School and the confluence with Perry Creek (see Figure 2-9); it remains the sole municipal water production well in the watershed. Even with the San Simeon wells in place, the municipal water supply of Cambria has a severity rating of Level III (resource capacity has been met or exceeded) due to unreliability of the groundwater supply to meet existing demands, as designated in the 2011 San Luis Obispo County Draft Master Water Plan (Carollo 2011).

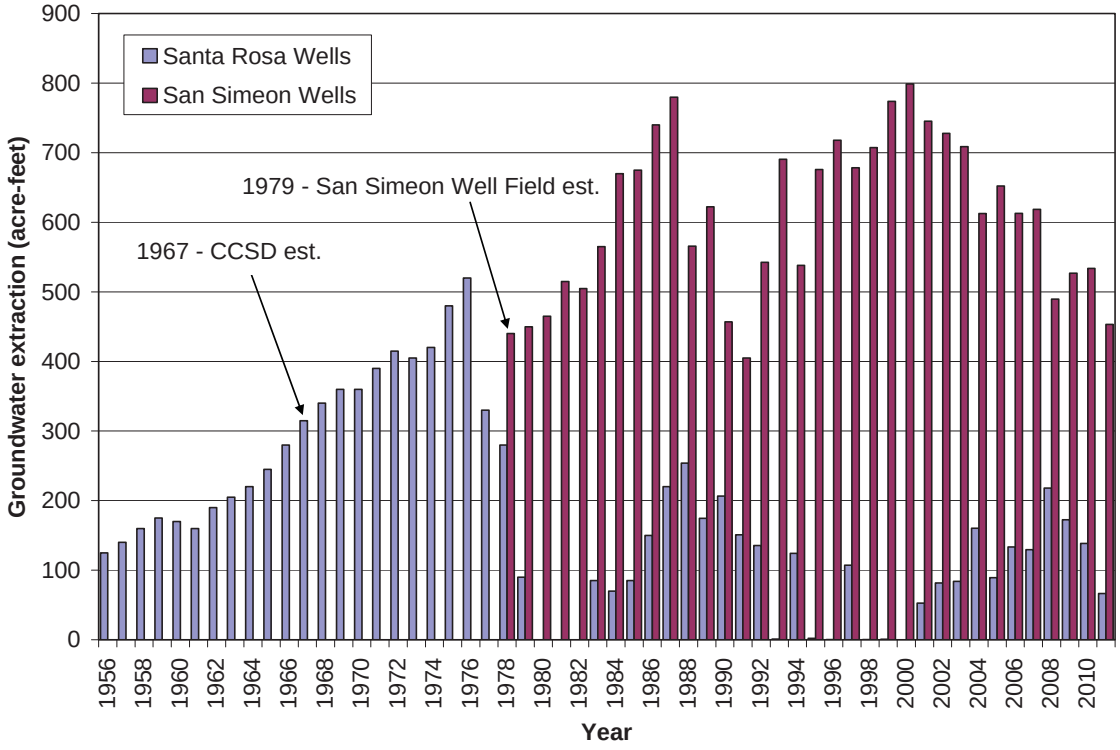

Figure 2-11. Annual groundwater extraction by CCSD from the Santa Rosa and San Simeon groundwater wells to provide Cambria water supply. Data from 1956–1988 provided by Yates and Van Konyenburg (1998) based on CCSD pumping records, and data from 1989–2011 provided by CCSD (2011). All years have recorded data.

Since the majority of municipal water is now supplied by the San Simeon wells (Figure 2-11), groundwater pumping in the Santa Rosa Creek watershed is primarily for private residential and/or agricultural use. Overall, the amount of groundwater extracted by entities other than CCSD is not well known. There are only few estimates of groundwater pumping by private entities available. USGS estimated that groundwater extracted by private entities for agricultural uses in 1988–1989 (after the establishment of the San Simeon wells) was approximately 3.5 times the amount pumped by the CCSD for municipal uses (Table 4 in Yates and Van Konyenburg 1998). The present-day amounts of urban and agricultural groundwater extraction are approximately equal (815 acre-feet per year [AFY] for urban, 830 AFY for agricultural) in the Cambria Water Planning Area, which includes Santa Rosa Creek, San Simeon Creek, Leffingwell Creek, and Villa Creek watersheds (ESA 2010). Agricultural pumping in the watershed typically peaks in the height of the growing season, usually July–August, and is close to zero in winter (Yates and Van Konyenburg 1998). Summer months also have the highest water demand due to increased occupancy and tourism in Cambria (San Luis Obispo County 2008).

Surface water diversion is limited in the watershed (for example, the recent update of the San Luis Obispo Water Master Plan makes no mention of surface water diversions in the Cambria Water Planning Area [Carollo 2011]), primarily because there is little to no instream flow during summer and fall when agricultural water demand is highest. Where surface diversions do occur, ditch pumps are generally employed (Yates and Van Konyenburg 1998). Ditch pumps have low yields and are, therefore, unlikely to significantly reduce surface water availability. The watershed does, however, host approximately 28 stock ponds, all situated on small, low-order tributaries. Taken together, these small ponds, which average 0.5–3.5 acre-feet in storage, intercept surface runoff from about 8% of the total watershed drainage area. In a given year, the amount of surface water intercepted by these ponds potentially ranges between 10 and 100 acre-feet based on their number and size. It is not known whether any of the ponds are supplemented with well water.

As discussed in Section 2.2, the CCSD and USACE are currently assessing the feasibility of a seawater desalination plant at the mouth of Santa Rosa Creek that would supplement the amount of municipal water currently being pumped from the San Simeon and Santa Rosa Creek aquifers, which is intended to improve the water supply reliability in the CCSD service area (CCSD 2008). There is the potential that, if desalinated water is ever used in place of pumped groundwater for the municipal water supply, the decreased extraction of groundwater from the Santa Rosa Creek aquifer could partially restore instream flows within Santa Rosa Creek. However, the extent to which, or even if, desalinated water may be used to replace the use of groundwater for the municipal water supply is unknown based on information available in CCSD (2008) and preliminary plans for the desalination plant. In addition, the majority of groundwater now pumped from the Santa Rosa Creek aquifer is by private entities for residential and/or agricultural water use. There is no indication that desalinated water would be used in place of privately pumped or diverted water from the watershed.

2.6.3 Lagoon hydrology

Similar to other lagoons along the California coast, the Santa Rosa Creek lagoon exhibits a “wet” and “dry” state during any given year, whereby winter and spring flows fill up the lagoon and the lack of flows during late summer and early fall often result in a dry lagoon. During the relatively wet year of 2005, D. W. Alley & Associates (2006) reported that the lagoon remained full throughout the summer. They also reported that lagoon water depth was predominantly controlled by streamflow and that tidal overwash and through-flow (i.e., subsurface flow through the sandbar) had a minimal effect. Flows into the lagoon during summer and fall are likely worsened

by low stream flows resulting from excessive groundwater pumping and diversions (Rathbun et al. 1991, Yates and Van Konyenburg 1998, D. W. Alley & Associates 2006, 2008). From 1993 to 2007, summer and fall streamflows immediately upstream of the lagoon ranged from 0 cfs (1994 and 2007) to 2 cfs (2005), with a median of 0.4 cfs (D. W. Alley & Associates 2008). In some lower flow years such as 2003 and 2004, entire sections of the lower lagoon dried up, reducing the area of suitable steelhead rearing habitat (D. W. Alley & Associates 2008). Prior to its relocation farther upstream in 2001, a CCSD groundwater well was located at the upstream end of the lagoon. Groundwater pumping at this location had observable impacts on water levels in the lagoon (Elliott 1995), which have increased since the well was relocated. Depending upon the location, water extraction for the desalination plant proposed by CCSD and the U.S. Army Corps of Engineer's could also decrease water levels in the lagoon (e.g., if the extraction point is located in an area that is hydrologically connected with the lagoon). As such, the extraction point location is likely to be the subject of additional data collection and impact analysis. Low flows and water diversion may also contribute to extended periods of saltwater and freshwater stratification in the lagoon, which results in warmer temperatures and anoxic conditions along the bottom (where denser saltwater settles) (see Section 2.8).

The sandbar typically breaches after high rainfall and remains open for a week or more depending on streamflows; then the sandbar reforms to create the lagoon (M. Walgren, pers. comm., 2010). Often, high wave energy can also contribute to sandbar breaching. Reformation of the sandbar and closure of the lagoon occurs when lower stream discharges and lower-intensity wave action facilitate onshore sediment transport and deposition at the mouth. Lagoon closure can take weeks to months, depending on the stream discharge and wave conditions. While the sandbar is open, the lagoon drains and is subject to the tides. From 1993–2007 the median date of sandbar closure was May 27, with the earliest closure on March 15 in 2007, and the latest closure on July 13 in 1998 (D. W. Alley & Associates 2008). During these years, date of sandbar closure was positively and significantly related to rainfall in the preceding water year, although the relationship was not strong ($r^2 = 0.347$; $P = 0.0209$; n = 15).

Open sandbar at the lagoon

2.7 Infrastructure and Channel Modifications

Infrastructure involves man-made constructs such as dams, roads, and bridges, and facilities related to water diversion and return. Channel modifications include straightening channels, construction of levees for flood control purposes, and bed and/or bank revetments as protection against bank erosion. Generally, these modifications are related to the development of floodplains including routing of roads near stream channels.

2.7.1 Creek crossings and fish passage barriers

There are numerous creek crossings (i.e., bridges and culverts) along Highways 1 and 46 and Santa Rosa Creek Road that may locally influence the dynamics of sediment deposition and erosion and prevent or impede fish migration and movement. Bridges and other crossings frequently cause hydraulic constrictions during high flow, which promote local geomorphic changes including sediment deposition upstream of the structure and erosion of the bed and banks

of the creek downstream of the structure as flow accelerates. Likewise, when crossing structures are not built to grade seamlessly with the channel bed, similar impacts are likely. Both causes may result in a significant "step" in the channel bed thereby disrupting geomorphic processes locally and impeding upstream fish passage.

Stream crossings and channel conditions in the Santa Rosa Creek watershed have been assessed by a number of entities to determine the extent to which they may limit fish migration and movement. The results of these assessments have been consolidated in the California Fish Passage Assessment Database (PAD)[4] (CalFish 2009). The potential barriers identified for the watershed in the PAD are summarized in Table 2-4 and mapped in Figure 2-12. The previous downstream-most barrier in the watershed, the Burton Street Bridge apron (PAD ID #707020) was modified in 2006 to provide fish passage under a wider range of flow conditions. In addition, the culverts and fish ladder at Ferrasci Road (PAD ID #700068) that were previously identified as a passage barrier were replaced with a free-spanning bridge in 2011. Without these two barriers, steelhead and other fish species, have unimpeded access to approximately 12 stream miles (19 km) on the mainstem creek between the ocean and East Fork Santa Rosa Creek, which presents the natural limit of anadromy.

Ferrasci Road crossing before (above) and after (below) replacement

There is a concentration of road drainage and crossing-related impacts along Green Valley Creek as part of the Highway 46 construction in the 1970s. The status of these creek crossings in impeding fish passage is largely unknown (Table 2-4), but it is possible that they exclude steelhead from nearly the entire Perry/Green Valley Creek sub-watershed (Figure 2-12). Perhaps the greatest geomorphic impact of these crossings has come from drainage modification approximately 3 mi (5 km) upstream from the junction of Highways 1 and 46. The increase in flow to Green Valley Creek at this location appears to have, at least in part, caused substantial downstream channel enlargement (i.e., bed incision and channel widening) in Green Valley Creek and erosion of the tributary channel downstream of the culvert. The impact appears to extend approximately 1 mi (2 km) downstream to where the channel gradient decreases, the channel width increases, and sediment deposition is observed to occur. Upstream of the road drainage and culvert, exposed bedrock and coarse bed material seem to be controlling the channel grade, thereby inhibiting channel enlargement due to the flow increase.

[4] While the PAD is not an error-proof database, many of the barriers identified in the Santa Rosa Creek watershed (Table 2-4 and Figure 2-10) have been previously field verified.

Table 2-4. Potential fish passage barriers in the Santa Rosa Creek watershed.

PAD ID No. [a]	Barrier location				Barrier description	Barrier status	Barrier priority	Information sources
	USGS-designated stream name	Unofficial stream name [b]	Station					
			mi	km				
712027	Unnamed	Unnamed tributary to Santa Rosa Creek	3.5	5.6	Culvert at Santa Rosa Creek Road crossing	Partial	Low	CCC, Greenspace
712044	Unnamed	Curti Creek	7.6	12.2	Culvert at Santa Rosa Creek Road crossing	Total	Low	CCC, Greenspace
712043	Unnamed	Unnamed tributary to Santa Rosa Creek	9.2	14.7	Culvert at Santa Rosa Creek Road crossing	Total	Low	CCC, Greenspace
712045	Unnamed	North Fork Santa Rosa Creek	12.6	20.2	Culvert at Santa Rosa Creek Road crossing	Total	Low	CCC, Greenspace
731782	Unnamed	Unnamed tributary	2.0	3.3	Culvert at Highway 1 crossing	Unknown	Medium	Caltrans
731365	Fiscalini Creek		6.0	9.6	Culvert at road crossing	Unknown	Medium	Caltrans
736678	Perry Creek		6.5	10.4	Highway 46 Bridge with potential passage constraints	Unknown	Medium	Caltrans
No ID	Perry Creek		8.3	13.4	Culvert at road crossing	Unknown	Medium	Caltrans
736483	Green Valley Creek		7.0	11.2	Highway 46 Bridge with potential passage constraints	Unknown	High	Caltrans
736475	Unnamed	Unnamed trib. to Green Valley Creek	7.5	12.1	Culvert at Highway 46 crossing	Unknown	Medium	Caltrans
736538	Unnamed	Unnamed trib. to Green Valley Creek	9.0	14.5	Culvert at Highway 46 crossing	Unknown	Medium	Caltrans
736487	Unnamed	Unnamed trib. to Green Valley Creek	10.0	16.0	Culvert at Highway 46 crossing	Unknown	Medium	Caltrans
736431	Unnamed	Unnamed trib. to Green Valley Creek	10.5	16.8	Culvert at Highway 46 crossing	Unknown	Medium	Caltrans
736457	Unnamed	Unnamed trib. to Green Valley Creek	10.6	17.0	Culvert at Highway 46 crossing	Unknown	Medium	Caltrans

PAD ID No. [a]	Barrier location				Barrier description	Barrier status	Barrier priority	Information sources
	USGS-designated stream name	Unofficial stream name [b]	Station					
			mi	km				
736621	Unnamed	Unnamed trib. to Green Valley Creek	11.1	17.8	Culvert at Highway 46 crossing	Unknown	Medium	Caltrans
716213	Green Valley Creek		11.9	19.2	Unspecified	Unknown	Unspecified	CDWR
736625	Unnamed	Unnamed trib. to Green Valley Creek	12.0	19.4	Culvert at Highway 46 crossing	Unknown	Medium	Caltrans
736583	Green Valley Creek		12.1	19.5	Culvert at Highway 46 crossing	Unknown	High	Caltrans

[a] Data source: California Fish Passage Assessment Database (PAD) (CalFish 2009).
[b] To help identify unnamed tributaries on USGS topographic maps (USGS 1979a, 1979b) that are referred to elsewhere in this document unofficial tributary names from D.W. Alley & Associates (2008) are presented.

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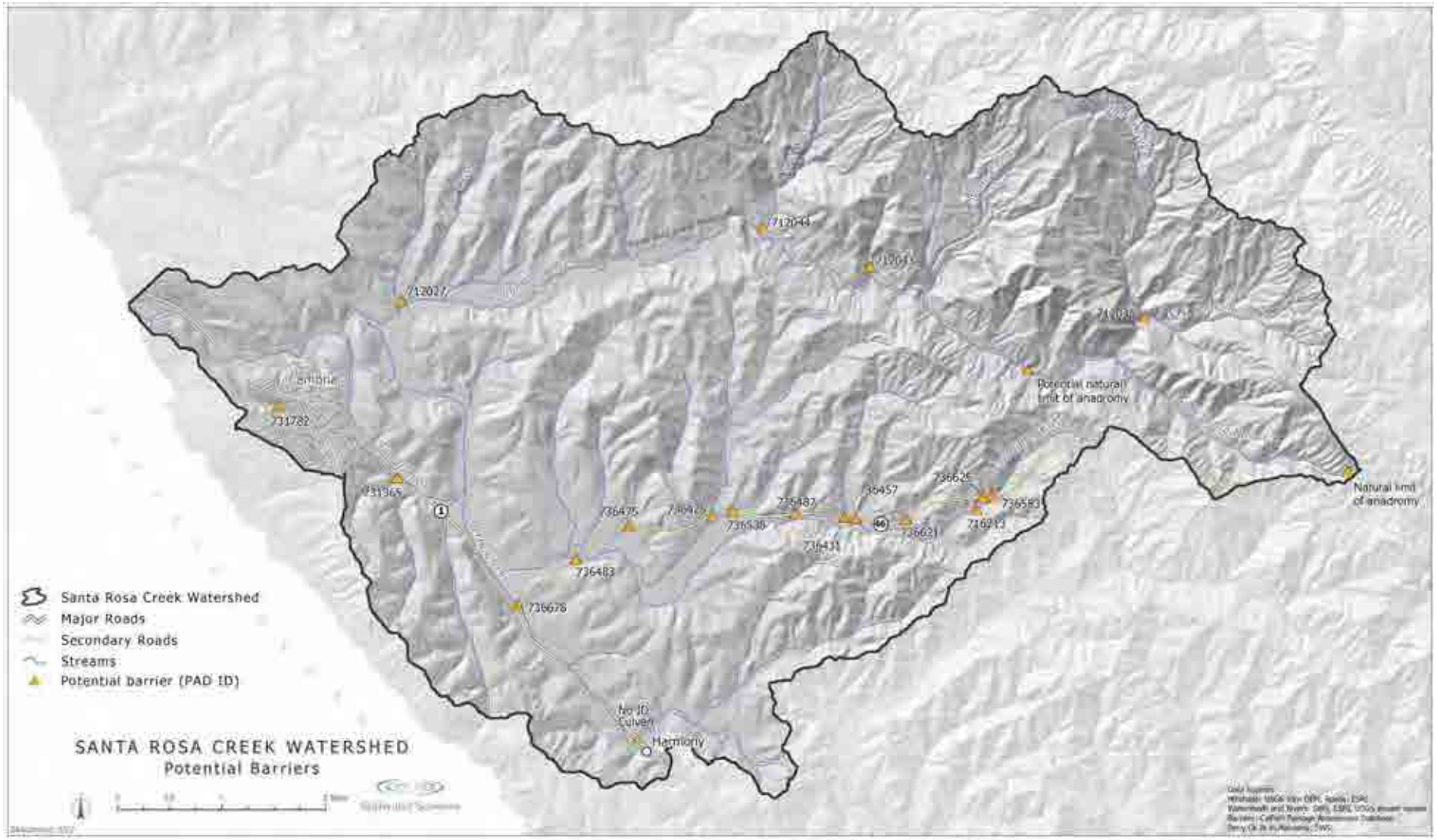

Figure 2-12. Potential fish passage barriers in the Santa Rosa Creek watershed (see Table 2-4 for details).

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2.7.2 Bank revetment and floodplain development

While no levees have been constructed along Santa Rosa Creek or its tributaries, there are numerous instances of bank revetment in the watershed, lining one or both banks of the creek (Nelson et al. 2009). The majority of riprap between the high school and old grammar school, which is composed primarily of boulder-size quarry rock, was reportedly installed immediately following the damaging floods of 1969 to repair banks that had eroded during the floods (D. Dunlap, pers. comm., 2009). In most instances, bank revetment is installed as a piecemeal solution to an on-going bank erosion concern that either threatens infrastructure or results in land loss. Unfortunately, bank revetment is also a symptomatic solution that does not account for the reason that high energy flow exists and is causing erosion. Therefore, bank revetments frequently cause flow to be deflected back across the channel resulting in further erosion downstream. The subsequent threat to downstream land and infrastructure promotes the continuing construction of further revetments and maintenance of existing revetments until such time that the channel is almost entirely revetted. Extensive revetment tends to cause channel incision, more rapid flows, channel bed armoring (i.e., coarse bed surface layer), and reduced topographic complexity of the channel bed resulting in significant reductions in habitat suitability for native aquatic organisms including salmonids.

In addition to in-channel structures, development along channel banks and the adjacent floodplain can have a significant impact on channel morphology. Floodplain development increases runoff associated with impervious area and increases channel confinement associated with bank hardening and structures built along channel banks, both of which have the potential to cause channel incision and/or widening due to increased flow velocities during high flow events. Since 1937, there has been concentrated development on the north bank (i.e., right bank) floodplain along Santa Rosa Creek from Highway 1 downstream. During the improvement of Highway 1 in the mid 1960's (bypass construction), many of the lower reaches of the channel were modified. In an effort to improve building conditions, an abandoned channel meander approximately 0.3 mi (0.5 km) downstream of the Highway 1 Bridge was filled-in sometime after 1937. These development features have undoubtedly played some role in controlling the current channel geomorphic character.

2.8 Water Quality

Surface water in the Santa Rosa Creek watershed has a number of beneficial uses, which are designated by Central Coast Regional Water Quality Control Board's (CCRWQCB) 1994 Basin Plan in order to inform water quality criteria (Table 2-5). A beneficial use is defined as the historical, present, and potential uses of water in the Basin as defined by the RWQCB. The intent is to ensure the continuance of beneficial uses and establish compatible water quality standards as well as the level of treatment necessary to maintain the standards.

Water quality monitoring by the CCRWQCB's Central Coast Ambient Monitoring Program (CCAMP) indicate that a number of water quality parameters occasionally exceed established criteria such that beneficial uses may no longer be supported in portions of the watershed at some times (CCRWQCB 2002). These include total dissolved solids (TDS), sulfates, sodium and chloride. In particular, a criterion for sulfate was exceeded 91% of the time on Santa Rosa Creek, at sites both upstream and downstream of Cambria. However, for all four of these parameters, the CCRWQCB acknowledged that because no upstream data exist it is unclear whether the elevated levels of these parameters are from anthropogenic sources and recommended that these parameters be evaluated throughout the watershed (CCRWQCB 2002).

Table 2-5. Beneficial uses of Santa Rosa Creek watershed surface waters.

Beneficial use	Estuary	Creek
Municipal and Domestic Supply (MUN)		X
Agricultural Supply (AGR)		X
Industrial Service Supply (IND)		X
Ground Water Recharge (GWR)	X	X
Freshwater Replenishment (FRSH)		X
Water Contact Recreation (REC-1)	X	X
Non-Contact Water Recreation (REC-2)	X	X
Commercial and Sport Fishing (COMM)	X	X
Warm Fresh Water Habitat (WARM)		X
Cold Fresh Water Habitat (COLD)	X	X
Estuarine Habitat (EST)	X	
Wildlife Habitat (WILD)	X	X
Preservation of Biological Habitats of Special Significance (BIOL)	X	
Rare, Threatened, or Endangered Species (RARE)	X	X
Migration of Aquatic Organisms (MIGR)	X	X
Spawning, Reproduction, and/or Early Development (SPWN)	X	X
Shellfish Harvesting (SHELL)	X	

Source: CCRWQCB (1994)

Additional monitoring by the CCRWQCB (Shwartzbart 1993), as well as CDFG (Nelson et al. 2009), and D. W. Alley & Associates (2008) identified a number of other water quality parameters that may be impairing instream conditions and potentially limiting the population of native aquatic species. These include temperature, dissolved oxygen (DO), and mercury, which are discussed in more detail below. In addition, development of this watershed management plan included a survey of benthic macroinvertebrates as a measure of overall water quality and stream health. The methods and results of this survey are also described below.

2.8.1 Temperature

Santa Rosa Creek is being considered for placement on the Clean Water Act 303d list of impaired waterbodies for temperature (CCRWQCB 2010). In streams such as Santa Rosa Creek with designated beneficial uses such as cold freshwater habitat (Table 2-5), objectives for water temperature are based, in part, on species-specific temperature tolerances (CCRWQCB 1994, SWRCB 1998). During their decision to recommend Santa Rosa Creek for placement on the 303(d) list, the CCRWQCB used 55–70°F (13–21°C), the optimal range for steelhead trout growth and other lifestages based on Moyle (1976), as their evaluation guideline (CCRWQCB 2010). However, some populations of steelhead have been shown to display local adaptation to higher water temperatures and there are many central California coast examples of steelhead surviving and growing well at water temperatures above 70°F (21ºC) (Moyle 2002, Spina 2007, Smith 1990, D. W. Alley & Associates 2008).

While there is still considerable uncertainty of what optimal temperatures for steelhead are in this region (A. Spina, pers. comm., 2010), available data for Santa Rosa Creek indicate that, in most years, summer water temperatures are suitable for successful steelhead rearing in the majority of

stream reaches (see Section 3.4 for additional detail). A relatively intact riparian corridor in most reaches and the influence of coastal fog likely help moderate stream temperatures in Santa Rosa Creek. In 2004–2006, D. W. Alley & Associates (2008) recorded maximum daily summer (July to September 10) water temperatures ranging from 67–75°F (20–24°C) in the lower reaches (stream miles 0.5–2.9); 69–74°F (20–23°C) in the middle reaches (stream miles 3.4–4.2); and 64–71°F (18–22°C) at two sites in the upper reach (stream miles 9.6–10.1 and 11.5–12.4). In 2005, CDFG recorded maximum daily summer (June through October) water temperature at stream miles 0.6, 8.0, and 14.5 (Nelson et al. 2009). Temperatures ranged from 55–79°F (13–26°C) at stream mile 0.6, 50–71°F (10–22°C) at stream mile 8.0, and 51–70°F (11–21°C) at stream mile 14.5 (Nelson et al. 2009).

D. W. Alley & Associates (2008) recorded summer (July 10 through October) water temperatures at two locations in the lagoon—adjacent to the Moonstone Beach parking lot and to Shamel Park—in 2001, 2002, 2005, and 2006. In all four years, temperatures reached or exceeded 77°F (25°C) at one or both of the monitoring sites for some portion of the summer. While temperatures of this magnitude likely make the lagoon inhospitable for summer rearing, steelhead were observed using the lagoon in both 2001 and 2006 (D. W. Alley & Associates 2008). Low instream flows and water diversion likely contribute to extended periods of saltwater and freshwater stratification, with warmer temperatures and anoxic conditions along the bottom where denser saltwater settles.

2.8.2 Dissolved oxygen

Dissolved oxygen (DO) levels measured by the CCAMP suggest that it may be a potential water quality limiting factor and that beneficial uses may no longer be supported (CCRWQCB 2002). At DO levels <5–6 mg/l, stress can begin to effect fish and other organisms. At high temperatures, steelhead can survive DO concentrations as low as 1.5–2.0 mg/l for brief periods, though concentrations closer to 8–12 mg/L are normally required for growth (Moyle 2002).

D. W. Alley & Associates (2008) recorded DO levels in the lagoon for 14 years (1992–2005) and during that time DO levels rarely met the 5 mg/l criterion or the 2 mg/l lethal limit for steelhead. They concluded that a reduction in tidal overwash could help to reduce the low DO saline layer at the bottom of the lagoon (tidal overwash increases lagoon salinity which can result in higher salinity, higher temperature, and lower DO layer at the bottom of the lagoon) and an increase in lagoon depth from increased stream inflow and increased shading could help to prevent filamentous algae growth (D. W. Alley & Associates 2008). Further, they found that, while DO levels frequently failed to meet guidelines and likely restricted the activity of steelhead in the lagoon, they were likely less limiting than temperature to steelhead survival in the lagoon since steelhead could avoid the low DO zones in the saline layer at the bottom of the lagoon and in the vicinity of high density filamentous algae (D. W. Alley & Associates 2008).

2.8.3 Mercury

A 1993 CCRWQCB study documented elevated levels of mercury in stream sediment, and to a lesser extent in water, in and downstream of Curti Creek (Schwartzbart 1993). Cinnabar, the common ore of mercury, was historically mined at several locations in the watershed, most notably at the Oceanic Mine located in the Curti Creek sub-watershed. Active mining at the site began in 1865 and continued intermittently through the 1900s. Records during this time indicate that a total of over 38,000 flasks of mercury were produced from the Oceanic Mine, nearly equal to the production from all other mercury deposits in the County combined (CCRWCQB 1999). During peak production, ore was milled and processed into pure forms of mercury in a furnace

located approximately ½-mile downhill from the mine (Eckel et al. 1941, as cited in CCRWQCB 1999). In 1964, the mine was sold to Buena Vista Mines, Inc., while the former mill site was sold to a different owner (Holcombe 1970, as cited in CCRWQCB 1999).

During a study of inactive mercury mines in San Luis Obispo County, the Central Coast Regional Water Quality Control Board documented iron-rich, red seepage from the mine, which reportedly pollutes and discolors Curti Creek for most of the downstream distance to Santa Rosa Creek, and the erosion of mercury-rich waste rock by Curti Creek at the former mill site (Schwartzbart 1993, CCRWQCB 1999). Stream sediment samples contained elevated mercury levels ranging between 1.095 to 8.48 mg/kg (ppm) downstream of the mine and former mill site (Schwartzbart 1993) (Table 2-6). These values exceed the concentrations above which adverse biological effects are expected to occur frequently in freshwater sediment (Buchman 2008).[5] Of the 49 inactive mines investigated during the study, the CCRWQCB concluded that Santa Rosa Creek was one of the most heavily metal-mined-impacted watersheds as a result of the Oceanic Mine former mill site (Schwartzbart 1993, CCRWQCB 1999). More recently, several sediment samples from lower Santa Rosa Creek have been tested for mercury (CCRWQCB 2002, L. Harkins and Sierra Club, unpubl. data, 2009). The results of all total mercury (THg) in sediment measurements taken in the watershed are summarized in Table 2-6 and sample points are mapped in Figure 2-13.

One sample point, HSC-4 in the lagoon, was analyzed for methyl mercury, the form of mercury that can bioaccumulate in living tissue, and was found to have 3 µg/kg (parts per billion), or 0.60% of THg (L. Harkins and Sierra Club, unpubl. data, 2009). Three-spined stickleback (*Gasterosteus aculeatus*) were collected in the lagoon by CCAMP in 1999 and 2001 and tested for mercury. The mercury concentration in the 1999 sample measured 0.318 ppm, while the 2001 sample measured 0.085 ppm; neither of which exceeded the CCRWQCB's (1994) 0.5 ppm criteria for mercury in aquatic organisms. Additional information is needed to more fully understand the magnitude of mercury methylation in the lagoon (which is the primary area in the watershed with the low dissolved oxygen conditions that facilitate the methylation process) and the extent to which mercury is being taken up by the aquatic foodweb.

CCRWQCB (1999) recommended that erosion control be implemented throughout the Ocean Mine area to stabilize the eroding mercury-rich waste rock at the former mill site. In addition, they determined that constructed wetlands could be a practical solution to retain and treat pollutants entering Curti Creek from the mine and former mill site. Remediation requirements from the CCRWQCB have been in place since 1997, however, no reclamation activities have been conducted at the mine or former mill site (CCRWQCB 1999).

[5] The following mercury levels in sediment are provided for reference:
0.08 mg/kg (ppm) = estimated pre-mining mercury levels in California stream sediments (SFBRWQCB 2008)
0.174 mg/kg (ppm) = mercury threshold effect level (TEL), the concentration above which adverse biological effects are expected to occur rarely, in freshwater sediment (Buchman 2008)
0.486 mg/kg (ppm) = mercury probable effect level (PEL), the concentration above which adverse biological effects are expected to occur frequently, in freshwater sediment (Buchman 2008)
20 mg/kg (ppm) = mercury hazardous waste limit

Table 2-6. Sediment mercury levels in Santa Rosa Creek watershed.

Sample point ID	Location	Date	Sediment THg (mg/kg) (ppm)
RB-SR-D1 [a]	Santa Rosa Creek upstream of Curti Creek	2/12/1992	0.192
RB-SR-C1 [a]	Curti Creek upstream of Oceanic Mine tributary	2/12/1992	0.511
RB-SR-A1 [a]	Tributary north of Oceanic Mine	2/12/1992	0.601
RB-SR-A2 [a]	Tributary at Oceanic Mine	2/12/1992	1.095/1.75 [d]
RB-FD-16 [a]	Tributary in vicinity of Oceanic Mine	5/19/1986	3 [e]
RB-SR-B [a]	Tributary south of Oceanic Mine	2/12/1992	6.79
RB-SR-C2 [a]	Tributary at Oceanic Mine just upstream of Curti Creek	2/12/1992	5.01
RB-SR-C3 [a]	Curti Ceek just downstream of Oceanic Mine tributary	2/12/1992	1.104
RB-SR-D2 [a]	Lower Curti Creek	2/12/1992	1.194/8.48 [d]
RB-SR-D3 [a]	Santa Rosa Creek downstream of Curti Creek	2/12/1992	0.161
HSC-1 [b]	Santa Rosa Creek 20 ft (6 m) upstream of Main Street Bridge	7/15/2009	0.12
HSC-2 [b]	Santa Rosa Creek at Creekside Reserve at Center St	7/15/2009	0.16
HSC-3 [b]	Santa Rosa Creek lagoon, 350 ft (106 m) upstream of bench at Shamel Park	10/12/2009	0.18
HSC-4 [b]	Santa Rosa Creek lagoon, at Shamel Park bench	10/12/2009	0.54
SWAMP-1 [c]	Mouth of Santa Rosa Creek	3/1/1998	0.55

[a] Source: Schwartzbart 1993
[b] Source: L. Harkins and Sierra Club, unpubl. data, 2009
[c] Source: CCRWQCB 2002
[d] Two measurements were taken at this sample point
[e] Another lab measured 41 mg/kg at this point

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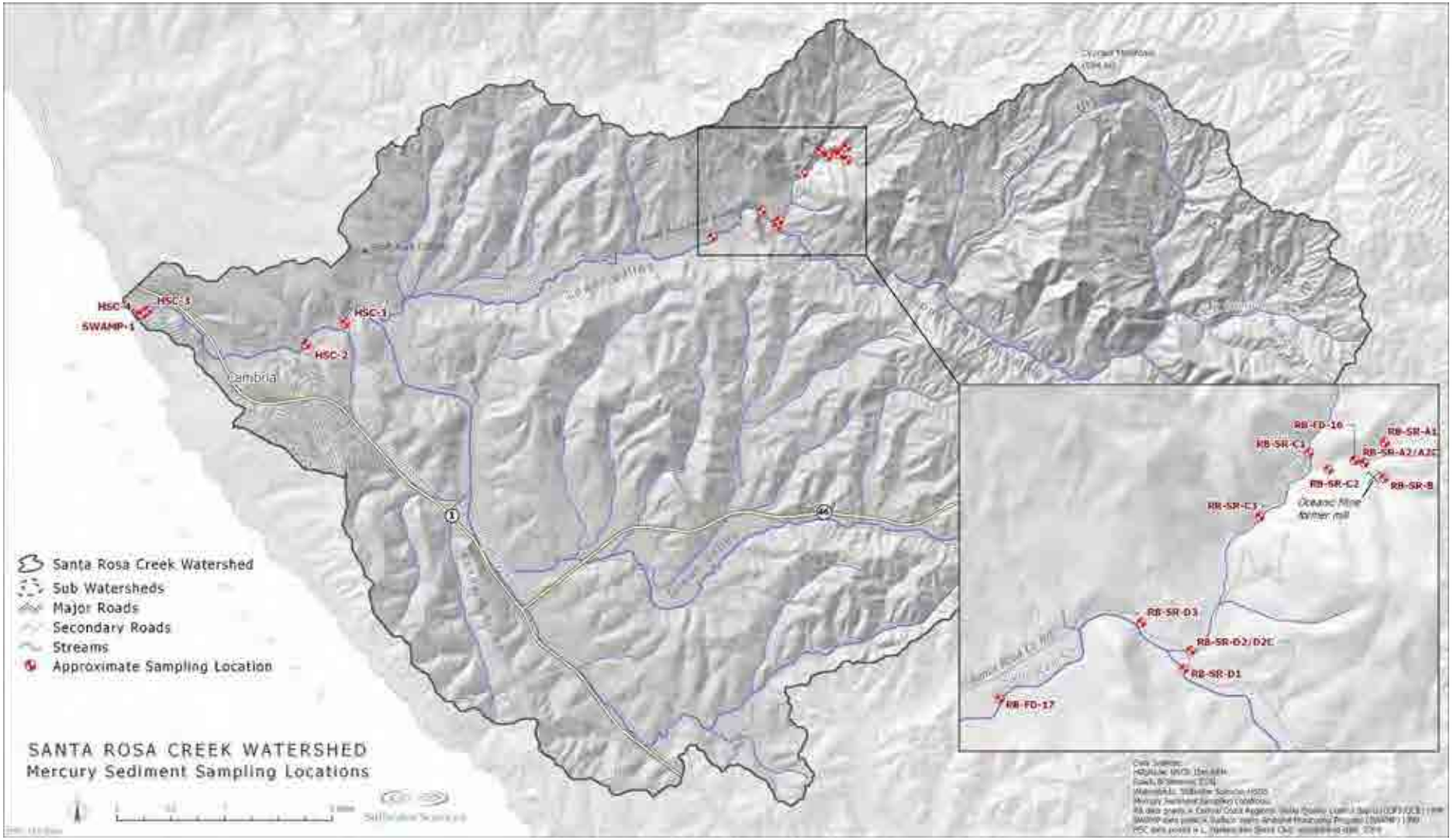

Figure 2-13. Mercury sample points in the Santa Rosa Creek watershed (see Table 2-6 for sampling entity and results).

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2.8.4 Benthic macroinvertebrates

Hydropsychid caddisflies

As a part of the development of this watershed management plan, the benthic macroinvertebrate population was sampled in lower Santa Rosa Creek to evaluate water quality and biological conditions of stream habitat in the watershed (Appendix B). Benthic macroinvertebrates are organisms that utilize the stream bed substrate as habitat. The distribution of benthic macroinvertebrates is dependent on seasonal weather variations (which influence water volume, velocity, and temperature), food availability, and water and habitat quality (Plotnikoff et al. 1997). Stream benthic macroinvertebrates respond to impacts related to pollution, sedimentation, and other changes in their habitat. The number, composition, and distribution of benthic macroinvertebrates can be a strong indicator of instream habitat quality. Benthic macroinvertebrates are also a primary food source for steelhead. Therefore, assessment of the benthic macroinvertebrate community can provide valuable insight into potential limiting factors for steelhead productivity.

In general, benthic macroinvertebrate diversity in Santa Rosa Creek is higher upstream, where the benthic macroinvertebrate assemblage is less tolerant of degraded conditions, and lower downstream, where the species assemblage is more tolerant of poor water quality conditions.

2.8.4.1 Sampling methods

On May 5, 6, and 7 of 2010, benthic macroinvertebrates were collected using an abridged version of the State Water Resource Control Board's (SWRCB) Surface Water Ambient Monitoring Program (SWAMP) bioassessment protocol (Ode 2007) at seven sites along Santa Rosa Creek (Figure 2-14):

Site 1 (stream mile 0.3)
Site 2 (stream mile 1.0)
Site 3 (stream mile 1.5)
Site 4 (stream mile 1.8)
Site 5 (stream mile 2.8)
Site 6 (stream mile 3.3)
Site 7 (stream mile 5.0)

Sampling sites were selected in part based on personal communications with Mary Adams of CCAMP and Jennifer Nelson of CDFG, both of whom have experience on Santa Rosa Creek. Physical accessibility and permission for access from landowners also played a role in site selection. Selected sampling sites reflect a variety of land uses and human influences, including urbanization, agriculture, and ranching. The four downstream-most sites are located within the town of Cambria.

Figure 2-14. Benthic macroinvertebrate sampling sites on Santa Rosa Creek.

Sampling took place at base flow conditions, at riffles no deeper than 2 ft, using the targeted riffle composite procedure (Ode 2007). A 450-ft reach of riffle habitat was defined at each site. Riffles are shallower stream habitats characterized by water that flows over and between rocks, creating mild to moderate water turbulence (Ode 2007). Riffles are commonly used for benthic macroinvertebrate sampling because they usually offer the highest diversity of benthic macroinvertebrate species (Ode 2007). Each 450-ft reach was randomly divided into eight transects, and sampling began at the lower-most transect and progressed upstream. At one location along each transect, a D-frame net with a mesh size of 0.5 micrometers was placed perpendicular to flow and flat on the substrate. Organisms in a 1-ft^2 sample area immediately upstream of the net were first removed from larger rocks and then the substrate within the sampling area was disturbed by hand for 60 seconds. Care was taken to ensure that all sample material flowed downstream and was captured by the net. Sample material from each transect was placed into a sample jar and preserved in 95% ethanol for lab analysis.

Water temperature, pH, dissolved oxygen, and velocity were measured at the downstream end of each reach using a digital Vernier LabQuest water quality meter. Wetted width of the stream, water depth, substrate, the presence of organic matter, and cobble embeddedness were measured and recorded at each transect. In addition, visual estimates and habitat scoring methods were used to assess the complexity of instream habitat, riparian vegetation, bank stability, and level of human influences at each transect.

2.8.4.2 Analysis and results

Transect samples were compiled for each site, sorted, and identified to 600 individual organisms per sample. Biometric values, including richness, composition, functional feeding group, and the Southern California Index of Biological Integrity (So Cal IBI), were calculated for each site. (Appendix B, Table 4.1 provides a list of all biometrics calculated, as well as a comparison of the results for Santa Rosa Creek with Coon Creek, San Luis Obispo County.) Each biometric is a characteristic of the benthic macroinvertebrate community that changes in a predictable way relative to a habitat stressor (Fore 1996). Biometrics are used as a diagnostic tool and are useful in

evaluating stream health and for comparing conditions between sites, between sampling events, and with other streams.

Richness—Richness, or diversity, is the total number of individual benthic macroinvertebrate species in a sample. The more diverse a benthic macroinvertebrate assemblage, the greater the likelihood that the local habitat is also diverse and robust. Sites 2 and 3 had the lowest richness values (17 and 18 total species, respectively), while sites further upstream had greater richness (e.g., 25 to 29 total species) (Figure 2-15).

Figure 2-15. Benthic macroinvertebrate taxonomic richness at sampling sites on Santa Rosa Creek in 2010.

Composition—Composition is the percentage, or relative abundance, of particular taxa in a sample. The two composition metrics reported here are the sensitive EPT Index and the Dominant Taxa index. The sensitive EPT Index is the percentage of three pollution-sensitive orders of benthic macroinvertebrates: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The higher the percent of sensitive EPT in a sample, the greater the likelihood that local water quality is good. In general, downstream sites on Santa Rosa Creek had lower sensitive EPT Index values than upstream sites (Figure 2-16).

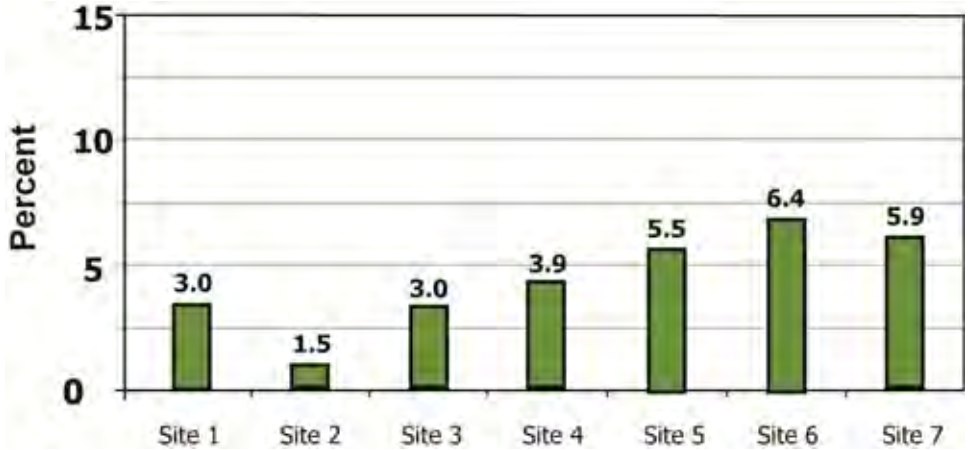

Figure 2-16. Benthic macroinvertebrate sensitive EPT Index values at sampling sites on Santa Rosa Creek in 2010.

The Dominant Taxa metric is the percentage of the third, second, and single most dominant benthic macroinvertebrate taxa in a sample. A stream with excellent water quality can support a greater number of taxa. If dominant taxa make up 40% or more of the total sample, it is an indication of instability in the macroinvertebrate community and that a stressor is present (MBNEP 2008). On Santa Rosa Creek, the three downstream-most sample sites had higher percentages of dominant taxa, indicating that a stressor is present (Figure 2-17).

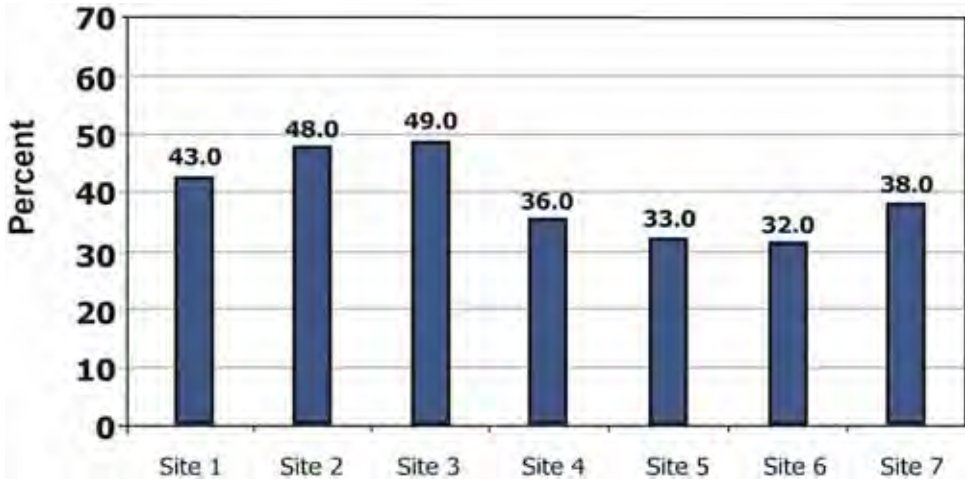

Figure 2-17. Percent of dominant benthic macroinvertebrate taxa at sampling sites on Santa Rosa Creek in 2010.

Functional Feeding Group—The functional feeding group metric is the proportion of taxa with different feeding strategies within a sample. Two types of functional feeding group metrics were calculated: the Scrappers Taxa metric and the Shredder Taxa metric. The Scrappers Taxa metric identifies the proportion of benthic macroinvertebrate taxa that graze upon periphyton. The greater the proportion of scrapper taxa, the higher the primary productivity at a sample location. On Santa Rosa Creek, downstream sites (e.g., Sites 1 through 4) had lower Scrapper Taxa values that upstream sites (e.g., Sites 5 through 7).

The Shredder Taxa metric is the percentage of benthic macroinvertebrate taxa that shred leaf litter. Higher proportions of shredder taxa indicate habitats with high retention of organic matter and food sources such as overhanging leaves and branches. On Santa Rosa Creek, Shredder Taxa values were much higher for Site 6 (3.1) and Site 7 (2.2), compared to Sites 3 and 4, where no shredder taxa where identified.

Southern California Index of Biotic Integrity—For each site, a standardized So Cal IBI score was determined. The So Cal IBI is a “condition” score that expresses the health of sites in a single qualitative number ranging from 0 to 100, with 0 representing an environment of very poor quality and low diversity and 100 being a very healthy environment with high diversity. The So Cal IBI is the sum of the following uncorrelated biometric values: (1) the number of Coleoptra (beetle) taxa; (2) the number of Ephemeroptera (mayflies), Plecoterea (stoneflies), and Trichoptera (caddisflies) (EPT) taxa; (3) the number of Predator taxa; (4) the percentage of sensitive individuals; (5) the percentage of Collector individuals; (6) the percentage of tolerant taxa; and (7) the percentage of non-insect taxa.

The So Cal IBI scores for the Santa Rosa Creek sites range from poor (34 at Site 2) to moderately good (63 at Site 6) (Figure 2-18). Site 2 (34) and Site 3 (37) exhibited the two lowest So Cal IBI scores, which suggest the likelihood of poor water quality at those sites. These sites are adjacent to the town of Cambria and, as such, experience higher levels of urban runoff. Urban runoff commonly contains higher levels of certain pollutants such as, but not limited to, heavy metals and petroleum-based pollutants, as compared to non-urban areas. These pollutants, along with physical changes to the riparian zone and stream channel that are common in urban areas, can affect the benthic macroinvertebrate community. The So Cal IBI score at Site 1, the most downstream site, is comparable to Sites 4 and 5, further upstream (Figure 2-18). The So Cal IBI scores suggest that the two most urban sampling sites, Sites 2 and 3, deserve a closer inspection of the potential influences on water quality in these areas and may warrant recommendations for land use best management practices to improve water quality in drainages leading to these sites. It should be noted however, that So Cal IBI scores can also be influenced by parameters other than water quality, such the size and quality of the riparian buffer. Thus, So Cal IBI scores should be utilized in conjunction with an understanding of local riparian conditions to guide management practices. The two upstream-most sites—Site 6 (63) and Site 7 (60)—exhibited moderately good water quality. These sites are not as affected by urban runoff but may be affected by adjacent lands uses of agriculture and ranching.

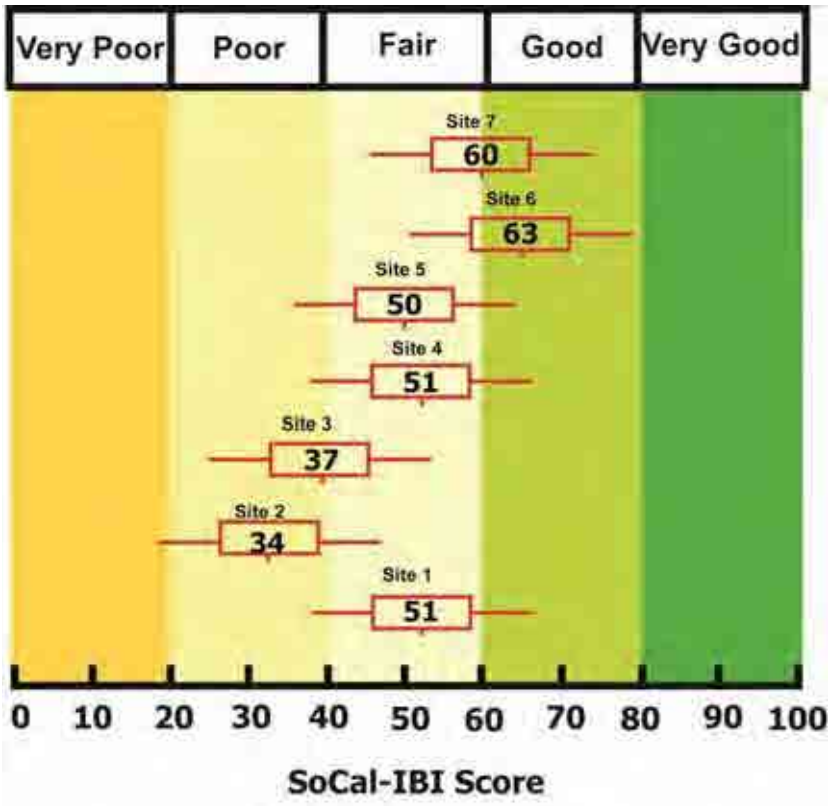

Figure 2-18. Southern California Index of Biological Integrity scores for benthic macroinvertebrate sampling sites on Santa Rosa Creek in 2010.

Another result of this study was to verify if the food supply in the Santa Rosa Creek is adequate to sustain populations of steelhead. The taxonomic lists for each site proved to have large populations of *Baetis* (mayflies) and *Simulium* (blackfly) populations, which are considered a valuable food source for steelhead (Appendix B).

The results in Appendix B can be used as a baseline for the establishment of a bio-monitoring program that tracks the impact of increased urbanization and other changes in land uses on the water quality of Santa Rosa Creek. In turn, repeated monitoring data can be useful in identifying areas that are in need of water quality improvement, and to help monitor the success of implemented restoration actions. Benthic macroinvertebrate sampling and analysis is increasingly recognized as an effective and efficient diagnostic tool for assessing water quality. The State of California is in the process of integrating benthic macroinvertebrate assessment into the water quality regulatory framework.

2.8.5 Storm water

2.8.5.1 First flush stormdrain monitoring

As a part of the development of this watershed management plan, water samples were collected in the late fall of 2010 to evaluate pollutants in the first stormwater runoff of the water year, or first flush, in the more urbanized portion of the watershed. The first flush is a unique opportunity to assess the quality of water entering creeks and streams as it carries materials, ranging from trash to road-way pollutants, which have accumulated on the landscape since the last rainfall. These constituents can be identified and analyzed in the lab, and can be used to guide the development of focused management actions to minimize the pollutants and/or prevent them from washing into waterways. Santa Rosa Creek 2010 first flush sampling sites are mapped in Figure 2-19 (sampling also occurred at the Burton Bridge and Bridge Street sites in 2011).

Figure 2-19. First flush sampling sites on lower Santa Rosa Creek.

Samples were collected using the Monterey Bay Sanctuary Citizen Watershed Monitoring Network's stormdrain monitoring protocol (Conrad et al. 2000). Water samples were collected directly from outfall pipes at all sample locations, except the Greenspace Creek Reserve, where samples were taken directly from the thalweg of the creek. Samples were collected in sterile Whirlpaks, stored in an ice chest, and transported to a lab for analysis at the earliest opportunity. Constituents identified in the Santa Rosa Creek first flush samples included total dissolved solids, nitrate, copper, zinc, and coliform bacteria (Table 2-7).

Table 2-7. 2010 first flush results for lower Santa Rosa Creek.

Analyte	High-way 1 Culvert #1	High-way 1 Culvert #3	Burton Bridge [a]	Green-space Creek Reserve	Bridge Street [a]	East Village Parking	RWQCB attention level
Total Dissolved Solids (mg/L)	1,600	not detected	3,700 (80)	1,100	210 (400)	6,200	500
Nitrate as N (mg/L)	not detected	0.5	0.48	not detected	0.78	1.1	2.25
Copper (mg/L)	0.0095	0.031	0.05	0.0023	0.041 (0.73)	0.066	0.01
Zinc (mg/L)	0.04	0.075	0.15	not detected	0.18 (0.51)	0.21	0.01
Total Coliform (MPN/100 ml) [b]			(>1,600)		(>1,600)		100
Total Oil and Grease (mg/L)			(not detected)		(8)		n/a

[a] 2011 results, as available, are provided in parentheses.
[b] Total coliform is measured using the most probable number (MPN) index, which is the concentration of coliform bacteria in a sample expressed as the number of bacteria per 100 mL.

Total dissolved solids are all inorganic and organic substances that are smaller than 2 microns (0.0002 cm) in size. Total dissolved solids is not generally considered a primary pollutant but is used as an indicator of the presence of a broad array of chemical contaminants. Sources of total dissolved solids are agricultural and residential runoff (including pesticides), leaching of soil contamination, point source water pollution discharge from industrial or sewage treatment plants, and natural weathering and dissolution of rocks and soils. Total dissolved solids in the lower Santa Rosa Creek first flush samples are presented in Figure 2-20. Four of six sites exceeded the attention level set by the CCRWQCB (1994). An attention level is the concentration of a substance in a particular medium (water, soil, etc.) that may be of concern when exceeded (CCRWQCB 1994).

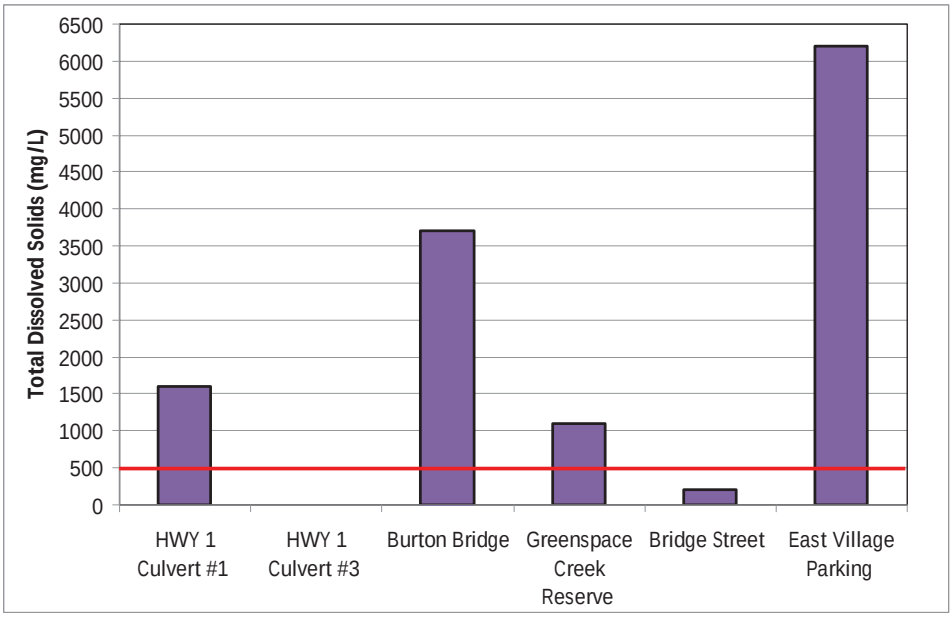

Figure 2-20. Total dissolved solids in 2010 lower Santa Rosa Creek first flush samples. The red line is 500 mg/L, the CCRWQCB (1994) attention level for total dissolved solids.

Nitrogen is a nutrient that acts as a fertilizer. When nutrient levels are high, excessive plant and algae growth can create water quality problems. Nitrogen enters water from human and animal waste, decomposing organic matter, and run-off of fertilizer from lawns and crops. Nitrate as nitrogen in the lower Santa Rosa Creek first flush samples is presented in Figure 2-21. While upstream sites have higher nitrate levels than downstream sites, none of the sites exceed the CCRWQCB (1994) attention level.

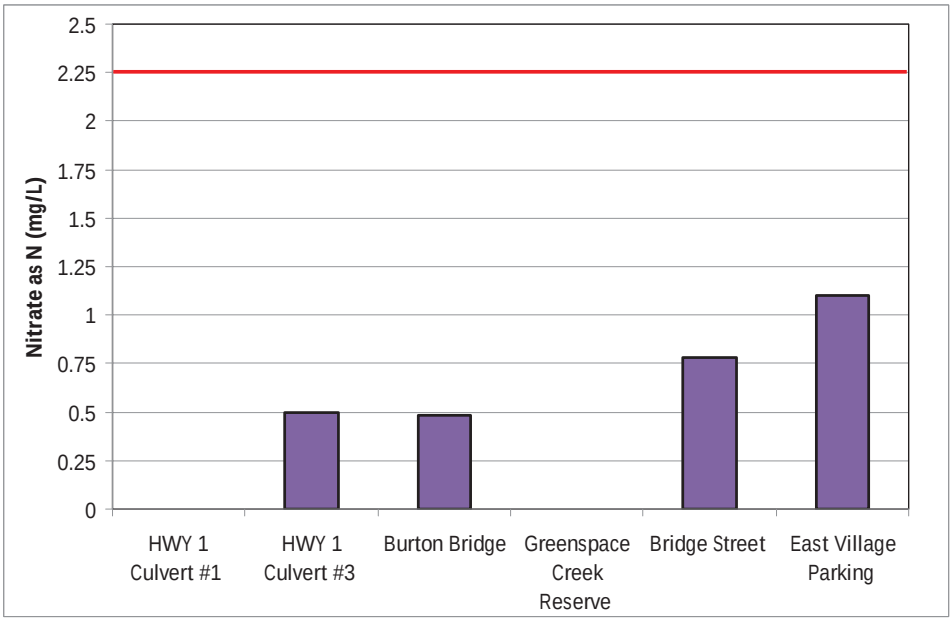

Figure 2-21. Nitrate as nitrogen in 2010 lower Santa Rosa Creek first flush samples. The red line is 2.25 mg/L, the CCRWQCB (1994) attention level for nitrate as nitrogen.

Metals such as copper and zinc may come from erosion of natural deposits, pesticides, industrial waste discharges, car brakes, agricultural waste, or corroding metal pipes and storage tanks. Trace metals can have direct toxic effects on aquatic plants and animals, and can bioaccumulate in aquatic species and have negative impacts throughout the food chain. Metals can also accumulate in sediment and be resuspended during storm events. Dissolved copper and zinc concentrations in the lower Santa Rosa Creek first flush samples are presented in Figures 2-22 and 2-23, respectively. The majority of sites on lower Santa Rosa Creek exceed CCRWQCB (1994) attention levels, but the attention levels are dependent on water hardness: copper and zinc are more toxic in softer water and less toxic in harder water (Ebrahimpour 2010). The Santa Rosa Creek results have not been adjusted for water hardness. Given the documented copper and zinc levels, a toxicity threshold that incorporates water hardness should be calculated.

Fecal coliform in the 2011 samples at the Bridge Street and Burton Bridge sites exceeded the limits of the lab test that was conducted. As such, it is not possible to determine if coliform levels in the creek exceeded the CCRWQCB (1994) attention level. However, the documented levels are high enough to suggest septic system or sewer leaks and fecal test should be conducted.

The first flush results represent an initial attempt at characterizing the types and quantities of pollutants in stormwater runoff in the more urban areas of the watershed. With additional resources a more robust first flush program could be initiated and conducted over time to more fully understand the trends in and degree of urban water quality influence on Santa Rosa Creek habitats and aquatic species.

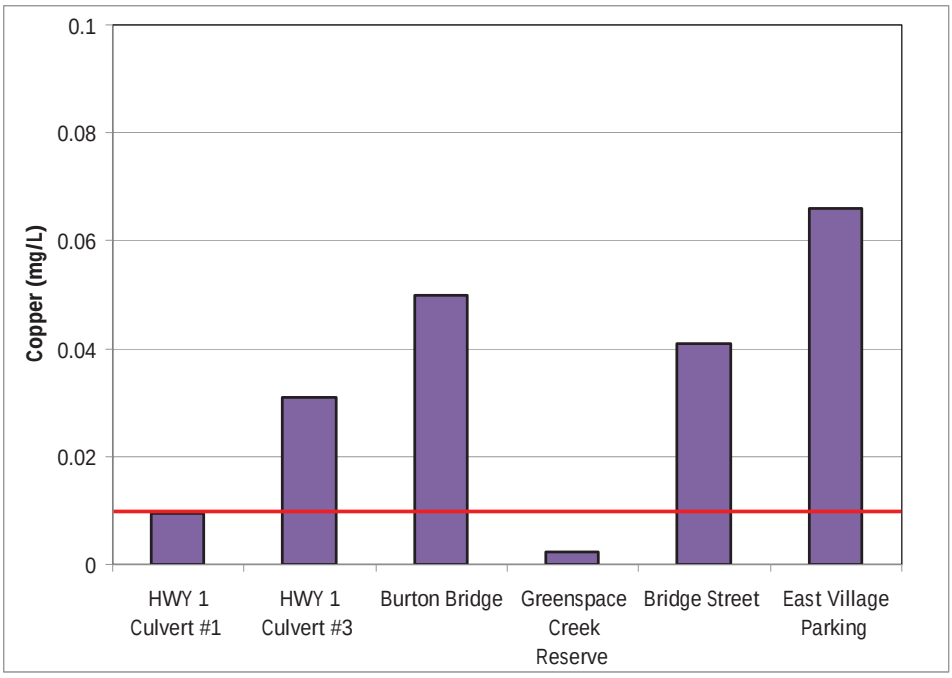

Figure 2-22. Dissolved copper in 2010 lower Santa Rosa Creek first flush samples. The red line is 0.01 mg/L, the CCRWQCB (1994) attention level for copper.

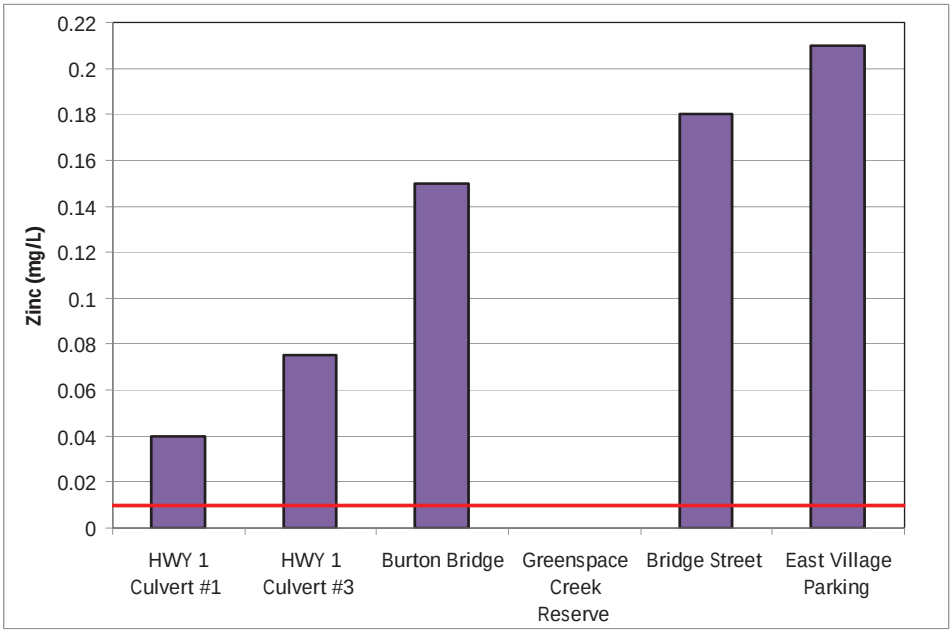

Figure 2-23. Dissolved zinc in 2010 lower Santa Rosa Creek first flush samples. The red line is 0.01 mg/L, the CCRWQCB (1994) attention level for copper.

2.8.5.2 Drainage-related erosion and flooding

Storm water related erosion, drainage problems, and flooding have been documented in a number of Cambria's residential neighborhoods. In 1999 an erosion and sediment study was commissioned for the Lodge Hill neighborhood after local residents, San Luis Obispo County staff, and local media documented storm water related drainage problems in the neighborhood (USDA NRCS 1999). While the study concluded that storm water erosion rates were not high enough to be a major source of sediment to nearby waterways and the Pacific Ocean, it documented steeply sloped unpaved roads, tire action from large vehicles, and construction sites with inadequate erosion control measures as sources of fine sediment during storm water flows (USDA NRCS 1999). The study report warned that without a coherent system of storm water management in the neighborhood, storm water drainage and erosion issues would worsen as more residences are constructed (USDA NRCS 1999). Study recommendations included developing a comprehensive master plan for built-out neighborhood conditions that incorporates a street drainage network, paved roads, and measures to address concentrated storm water flow and reduce impacts on forest resources (USDA NRCS 1999).

Flood damage to homes and businesses in March 2001 prompted San Luis Obispo County to commission another drainage study for additional Cambria neighborhoods (RMC 2004). The study found that the combination of steep topography in many Cambria neighborhoods, the lack of underground drainage facilities, and the location of many parcels below street grade results in localized poor drainage and flooding of some residences, buildings, and roadways during storm events (RMC 2004). Storm water-related flooding and erosion were found to be a result primarily of upslope concentrated flows entering downhill lots without any storm drain facilities. The study proposed a number of projects to capture storm water runoff from residential lots and roadways and convey it to a creek or to the ocean. Projects include paving roads with rolled asphalt berms, installing drop inlets or catch basins, and constructing roadside ditches and drainage channels (RMC 2004). Project implementation is likely to be the responsibility of individual property

owners, developers, and/or a local entity, working in collaboration with the County Flood Control and Water Conservation District. The 2004 study noted that new development is expected to substantially increase storm water runoff in Cambria neighborhoods, particularly in Lodge Hill where many roads are unpaved, and that any proposed development in the Cambria area should be planned with drainage improvements.

Together the 1999 and 2004 drainage studies indicate that storm water is not being adequately planned for or managed in Cambria's residential neighborhoods. Although current rates of runoff and erosion from neighborhoods do not appear to be significantly affecting habitat conditions in Santa Rosa Creek, both studies warned that storm water issues can be expected to worsen if development continues in the Cambria area, unless meaningful steps are taken to plan for and address road- and home lot-related storm water runoff.

2.9 Vegetation

2.9.1 Vegetation types and distribution

The Santa Rosa Creek watershed is dominated (63% of watershed total) by grassland/herbaceous vegetation, much of which is used for cattle ranching and dairy cattle pasture (Homer et al. 2004) (Table 2-8, Figure 2-24). Throughout the watershed, scrub/shrub (coastal and chaparral) is found in steeper, upland areas and mixed-hardwood forest types, such as California bay tree (*Umbellularia californica*), occur in riparian areas. In the inland portions of the watershed, mixed-hardwood forest, such as coast live oak (*Quercus agrifolia*), and stands of evergreen forest occur on ungrazed hillslopes. Closer to the coast, stands of Monterey pine (*Pinus radiata*) evergreen forest occur near Cambria, and woody and emergent herbaceous wetland vegetation, such as willows (*Salix* spp.) are found primarily around the lagoon (Figure 2-24). While the National Landcover Dataset of 2001 (Homer et al. 2004) was used to generate the summary of data in Table 2-8 and map of vegetation in the watershed (Figure 2-24), the vegetation descriptions provided below are based, in part, on the compilation and description of multiple vegetation maps for the watershed by TLCSLOC (2010).

Table 2-8. Vegetation types in the Santa Rosa Creek watershed.[a]

Landcover/Vegetation type		Area (acres)	Area (hectares)	% of watershed area[b]
Grassland/Herbaceous		19,256	7,793	63
Scrub/Shrub		3,235	1,309	11
Mixed Forest		2,899	1,173	10
Developed	Open Space	1,951	790	6
	Low Intensity	409	165	1
	Medium Intensity	124	50	0.4
	High Intensity	3	1	0.01
Evergreen Forest		1,958	792	6
Cultivated Crops		360	146	1
Woody Wetlands		153	62	1
Pasture/Hay		37	14	0.1
Emergent Herbaceous Wetland		4	2	0.01

[a] Source: 2001 National Land Cover Data (Homer et al. 2004)
[b] Proportion of land cover category within the total watershed area determined in GIS.

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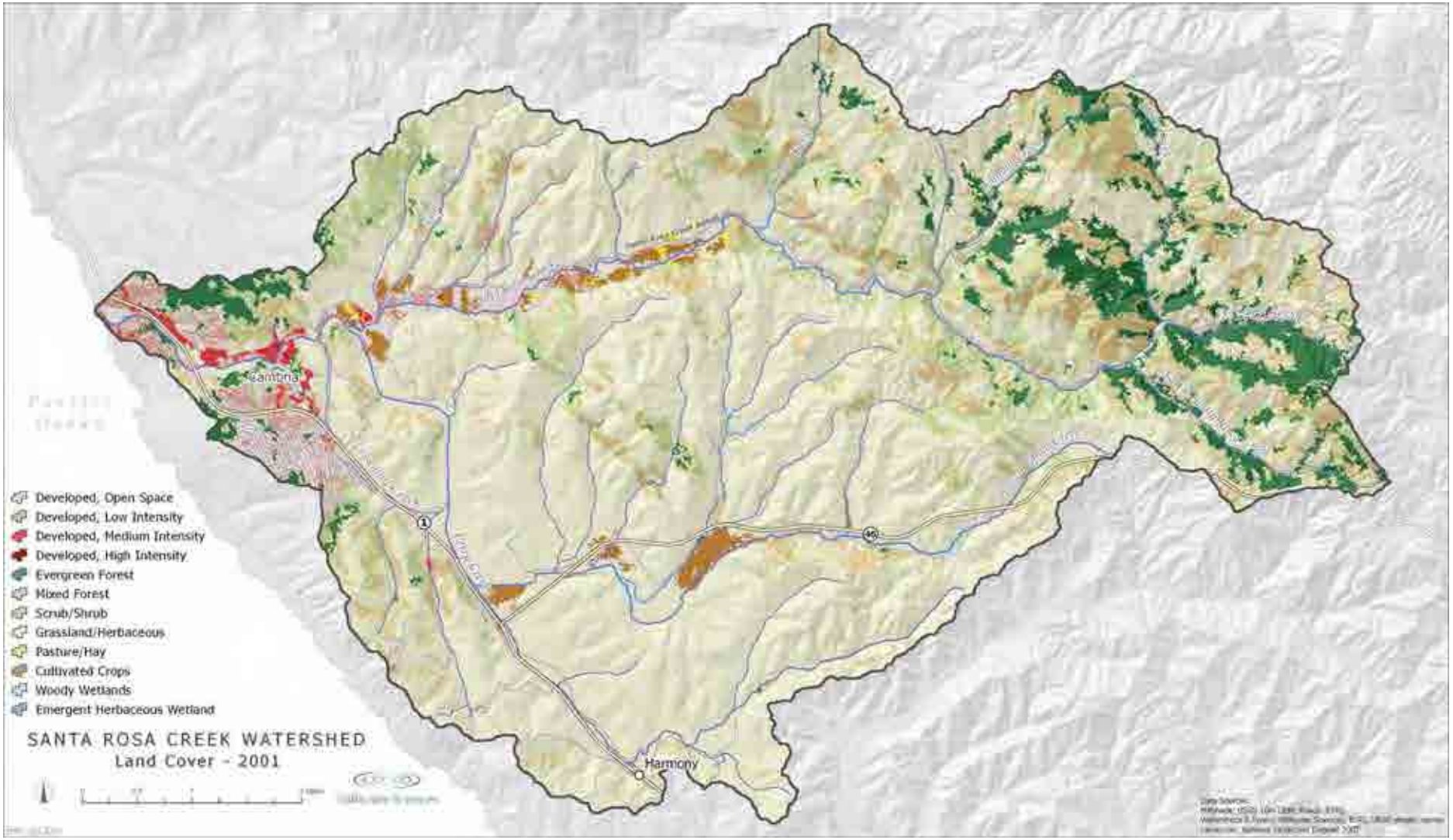

Figure 2-24. Vegetation/land cover types within the Santa Rosa Creek watershed.

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2.9.1.1 Grassland/Herbaceous

Grasslands dominate much of the watershed (Figure 2-24). Like most grasslands in California, those in the Santa Rosa Creek watershed are likely dominated by non-native grass species that are now considered naturalized (TLCSLOC 2010). For example, non-native wild oat (*Avena* spp.), soft chess (*Bromus hordeacous*), rip-gut brome (*B. diandrus*), and Italian ryegrass (*Lolium multiflorum*) are the dominant grass species in the Fiscalini Ranch Preserve (the old East-West Ranch), along with common weedy species such as filaree (*Erodium cicutarium*), vetch (*Vicia* sp.), black mustard (*Brassica nigra*), prickly lettuce (*Lactuca serriola*), storksbill (*Erodium botrys*), summer mustard (*Hirschfeldia incana*), milk thistle (*Silybum marianum*), wild radish (*Raphanus sativa*), mayweed (*Anthemis cotula*), Italian thistle (*Carduus pyncnocephalus*), coast morning glory *(Calystegia macrostegia* ssp. *cyclostegia*), and scarlet pimpernel (*Anagallis arvensis*) (Morro Group 2009). Despite being dominated by non-native species, grasslands in the Fiscalini Ranch Preserve have been documented to contain several native grasses and forbs that are indicative of native coastal prairie, such as California oat grass (*Danthonia californica*), hairgrass (*Deschampsia elongata*), purple needle grass (*Nassella pulchra*), sky lupine (*Lupinus nanus*), California poppy (*Eschscholzia californica*), tidy tips (*Layia platyglossa*), and California buttercup (*Ranunculus californicus*) (Ford and Hayes 2006, Morro Group 2009). Coastal prairie vegetation, which occurs in fog-influenced areas from the Oregon border to northern Santa Barbara County, is increasingly rare and endangered (Ford and Hayes 2006). Even though coastal prairie also tends to be dominated by non-native grasses, it supports a high diversity of native perennial grasses and forbs, many of which are endangered, threatened, or rare species, particularly when exposed to appropriate magnitudes and durations of cattle, goat, and/or sheep grazing and burning (Hayes and Holl 2003). Given the magnitude of coastal fog influence and cattle grazing in the watershed, it is quite likely that coastal prairie vegetation is supported in at least some areas mapped as grassland/herbaceous. As a result of this loss and the number of protected plant and animal species associated with this vegetation type, there is increasing interest and effort to preserve and maintain coastal prairie through land acquisition, and grazing and fire management.

2.9.1.2 Scrub/Shrub

Chaparral, coastal scrub, and coast mixed shrub occur in patches throughout the watershed (Figure 2-24). Chaparral and southern coastal scrub communities generally grow in dense thickets, and are dominated by drought-tolerant long-lived shrubs, such as manzanita (*Arctostaphylos* spp.), California sagebrush *(Artemisia californica*), sage *(Salvia* spp.*),* and coyote bush (*Baccharis pilularis*) (TLCSLOC 2010). These communities are also highly flammable and adapted to occasional disturbance by fire, which facilitates seed germination and regeneration of some dominant species. Like coastal prairie, these coastal scrub vegetation types are increasingly rare and endangered (Ford and Hayes 2006). As such, many coastal scrub and coastal prairie vegetation alliances are afforded protection by the State of California, either as CDFG-recognized special natural communities or as the host of state-protected plant and animal species (CDFG 2003a; Hillyard 2009).

Scrub/Shrub and Mixed Forest vegetation in the upper Santa Rosa Creek watershed

2.9.1.3 Mixed forest

Both coast live oak and blue oak woodlands are components of areas mapped as Mixed Forest in the Santa Rosa Creek watershed. Coast live oak woodlands can occur on more moist, often north-facing slopes or in drier, more exposed areas (TLCSLOC 2010). In moister areas, coast live oak (*Quercus agrifolia*) generally forms dense forests with California bay-laurel (*Umbellularia californica*), madrone (*Arbutus menziesii*), and big-leaf maple (*Acer macrophyllum*), with a variety of shade-tolerant understory plants (TLCSLOC 2010). In drier areas, coast live oak woodlands are characterized by sparsely scattered oaks among either shrubby or herbaceous understory plants, or integrated with grasslands (TLCSLOC 2010). Blue oak (*Q. douglasii*) woodlands occur in the warmer, drier eastern portion of the watershed.

Areas of Mixed Forest also include bands of riparian vegetation that occur along most of the larger channels in the watershed (Figure 2-24). CDFG (Nelson et al. 2009) noted abrupt changes in the composition and condition of riparian vegetation as one moves downstream:

> From the headwaters down to stream mile 7.8, the creek flows through a sinuous confined canyon where oaks, California bay and alder are the dominant tree species. Grasses, sedges and other herbaceous species comprised the understory. At stream mile 7.8, the creek abruptly discharges from the narrow canyon into a broad valley with a poorly defined creek channel, extensive gravel bars and flood plains, short, denuded stream banks and intermittent willow trees, mule fat and grasses. … From stream mile 6.5 downstream to stream mile 3, the valley floor is still broad, however the stream channel is incised. Riparian species include alder, willow, cottonwood, sycamore and a dense herbaceous understory. Downstream of this point the valley constricts somewhat and the town of Cambria surrounds the creek. Much of channel in this area is lined with rip rap and the riparian has been encroached upon by development. The native vegetation along the creek includes willow, poison oak, stinging nettle and blackberry, however extensive stands of non-native trees, shrubs and ivy dominate the riparian zone to the exclusion of native vegetation.

Riparian canopy conditions are further described in Section 2.9.4 below.

2.9.1.4 Evergreen forest

Much of the Evergreen forest mapped in the lower watershed is Monterey pine (*Pinus radiata*) (Figure 2-24). There are approximately 3,500 acres of Monterey pine forest in and around the community of Cambria (both within and outside the Santa Rosa Creek watershed), which constitutes approximately 17% of the remaining native Monterey pine forest in California and Baja California (Cambria Forest Committee 2002). In natural stands, Monterey pine forms a closed canopy forest with coast live oak, and toyon (*Heteromeles arbutifolia*), with various shrubs and herbs in the understory (Cambria Forest Committee 2002, TLCSLOC 2010). Approximately 1/3 of the Cambria Monterey pine forest intergrades with developed areas (Cambria Forest Committee 2002). The Cambria Forest Management Plan was developed in 2002 to guide conservation and management of the Cambria Monterey pine forest, in part as a response to continued threats to the forest by pine pitch canker disease and urban development. Monterey pine has also been planted extensively outside of its indigenous range, both in California and around the world.

Evergreen forest in the upper watershed is likely a mix of hardwoods, gray pine (*Pinus sabiniana*), and potentially Douglas fir (*Pseudotsuga douglasii*).

2.9.1.5 Woody and emergent herbaceous wetlands

During periods of low flow and when the sandbar at Moonstone Beach is closed, a seasonal lagoon forms at the downstream end of Santa Rosa Creek. The seasonal lagoon supports a fringe of riparian vegetation at its upstream end and wetland species, such as cattail (*Typha* spp.) that are tolerant of continuous inundation, along the water's edge. Small patches of salt marsh vegetation that are tolerant of the brackish water conditions closer to the ocean occur along the waters edge at the downstream end of the seasonal lagoon. Small patches of dune vegetation occur on the beach, outside of the seasonal lagoon inundation area (Z. Diggory, pers. obs., 2009).

2.9.2 Rare plant species and vegetation types

TLCSLOC (2010) identified special-status plant species with the potential to occur in the watershed using CDFG's California Natural Diversity Data Base (CNDDB) and the California Native Plant Society's (CNPS) Inventory of Rare and Endangered Plants online database. Queries of these databases, which included the Cambria and Cypress Mountain 7.5 minute quadrangles, identified 21 plant species with the potential to occur in the watershed that are listed by CNPS as rare, threatened, or endangered in California and elsewhere (CNPS List 1B). These are primarily perennial herb species, but also include five manzanita species and several other shrubs, as well as Monterey pine (TLCSLOC 2010). Of these, Cambria morning-glory (*Calystegia subacaulis* ssp. *episcopalism*), Obispo Indian paintbrush (*Castilleja densiflora* ssp. *obispoensis*), compact cobwebby thistle (*Cirsium occidentale* var. *compactum*), and Monterey pine (*Pinus radiata*) have been documented to occur in the watershed, specifically in the Fiscalini Ranch Preserve (Morro Group 2009).

As described earlier, Cambria supports a notable percentage of the remaining natural stands of Monterey pine in California and Baja California (Cambria Forest Committee 2002). Natural Monterey pine forests are recognized in the CNDDB as a special natural community (CDFG 2003a), and this population in particular is protected by the Coastal Commission as an Environmentally Sensitive Habitat Area (ESHA). In addition, the Fiscalini Ranch Preserve supports Valley Needlegrass Grassland vegetation, which is composed of purple needlegrass (*Nassella pulchra*), a native bunchgrass that was once an abundant component of the California grassland flora and is recognized in the CNDDB as a special natural community (CDFG 2003a, Morro Group 2009).

2.9.3 Non-native invasive plant species

Combined, over 200 non-native invasive plants observed or with the potential to occur in the Santa Rosa Creek watershed have been identified by CDFG (Nelson et al. 2009), TLCSLOC (2010), Morro Group (2009), and Cambria Forest Committee (2002). This includes the non-native grassland species described in Section 2.9.1. Several of these species are particularly troublesome as they are already widely distributed, are highly effective at replacing native vegetation, are known to disrupt and impair native habitat, or require aggressive treatment to control. These include:

- arundo/giant reed (*Arundo donax*)
- pampas grass (*Cortaderia selloana and/or C. jubata*)
- Scotch broom (*Cytisus scoparius)*
- cape ivy (*Delairea odorata*)
- eucalyptus (*Eucalyptus* sp.)
- French broom (*Genista monspessulana*)

During a survey of the lower 14 mi (22 km) of Santa Rosa Creek, CDFG noted the presence and general distribution of non-native plants in the riparian corridor (Nelson et al. 2009).
The greatest diversity of non-native invasive plants in the riparian corridor was found to occur in the lower 6 mi (10 km) of the creek, and at stream mile two specifically (Nelson et al. 2009). The residential and commercial land uses that occur close to the creek in this area are likely responsible for the intentional and/or accidental introduction of most of these plants, many of which are commonly found in gardens (e.g., palm trees, nasturtium, and periwinkle). With only two exceptions, no non-native plant species were observed between stream miles 11 and 14 (Nelson et al. 2009).

Eucalyptus, planted throughout California in the late 1800's for wharf construction and fence post production and to provide wind breaks, was recorded as relatively dense stands on the streambank in some locations. Eucalyptus often precludes the establishment and/or growth of understory species because of its allelopathic properties; oils in the leaves and bark that fall to the ground prevent or greatly reduce the ability of other plants to grow. CCSD is currently planning a eucalyptus removal project along the lower creek, downstream of the Highway 1 Bridge (B. Boer, pers. comm., 2010).

Cape ivy infestation near the lagoon

CDFG noted that "cape ivy was found from stream mile 10 downstream, but was most extensive in stream miles 5 and 6" (Nelson et al. 2009). In some areas, cape ivy was found to completely cover the streambank. In these and other cases, the extent of cape ivy is likely sufficient to preclude the establishment of native plants that would better shade the creek and help moderate stream temperatures as well as provide habitat for native wildlife species. Although Nelson et al. (2009) noted pampas grass in several areas in the lower 6 mi (9 km) of the creek, this was most likely jubata grass, which is easily confused with pampas grass but is more prevalent along the San Luis Obispo County coast (DiTomaso 2000). Large infestations of pampas grass and jubata grass threaten California's coastal ecosystems by crowding out native species, particularly in sensitive coastal dune areas.

Only one patch of arundo was recorded by CDFG, near stream mile 14 (Nelson et al. 2009). Arundo is a highly invasive species in central and southern California riparian environments and can rapidly displace native vegetation and alter riparian habitat conditions. This occurrence of arundo should be an extremely high priority for eradication to prevent it from spreading farther downstream.

In addition to cape ivy and pampas grass, the Cambria Forest Committee (2002) also noted that French broom and Scotch broom are the most abundant invasive species in the Cambria area, and the ones that will require the most aggressive treatments.

2.9.4 Riparian vegetation conditions

When of sufficient width and density, riparian vegetation performs many functions in natural river systems. It provides a buffer between the stream and adjacent land uses, reduces erosion, and filters runoff and nutrients, thereby reducing the delivery of fine sediment and pollutants to the stream. Riparian vegetation provides habitat for terrestrial wildlife and nesting birds, movement corridors for wildlife, and woody debris for instream habitat. Riparian canopy cover supplies leaf litter and terrestrial invertebrates for the aquatic foodweb and moderates stream temperatures by shading the channel and reducing near-stream windspeed (Poole and Berman 2001). The conservation and restoration of riparian vegetation, therefore, provides a relatively straightforward and cost-effective way for landowners and other watershed stakeholders to conserve and enhance myriad ecosystem conditions.

Following California statehood in 1850, Americans quickly settled the watershed and greatly increased the pace of land clearing, which was reportedly achieved by cutting and/or burning the native vegetation (Coffman 1995, D. Dunlap, pers. comm., 2009). Historical accounts from across the coastal region tell of coordinated efforts by land owners to clear valley-bottom forests along major rivers (Boughton et al. 2006), which was likely practiced along Santa Rosa, Perry, and Green Valley creek valleys. Historical illustrations of ranches in the watershed from the late 1800s and the earliest aerial photographs of the watershed in 1937 indicate only narrow strands of riparian vegetation along streams. Aerial photography taken in 2009 reveals a considerable increase in riparian vegetation extent and density compared with 1937 (Figure 2-5).

Outside of Cambria, the ability of riparian vegetation to recruit and grow is limited by cattle grazing in the riparian corridor, the effect of which is apparent in the denuded streambanks in much of the Perry/Green Valley Creek sub-watershed, and to some extent by groundwater conditions, such as in the middle reaches of Santa Rosa Creek. Encroaching riparian vegetation is also occasionally removed from the channel in wet water years in the vicinity of bridges and other public works by the San Luis Obispo County Public Works Department to reduce the risk of flooding (B. Boer, pers. comm., 2010).

While riparian vegetation extent has recovered since the 1930s, it is now limited by urban development and infrastructure, which limits the area where riparian vegetation can establish (see Figure 2-25) and is a source of non-native invasive plant species (see Section 2.9.3 above). Riparian canopy cover conditions on Santa Rosa Creek vary by reach and are strongly influenced by stream flow. Between 1994 and 2006, tree canopy closure (i.e., the percent of the channel covered by the riparian tree canopy) was measured every four years in the lower 13 mi (20 km) of Santa Rosa Creek in association with steelhead population and habitat surveys (D. W. Alley & Associates 2008). CDFG also measured riparian canopy density at approximately one-third of the habitat units mapped during a survey of steelhead in the lower 14 mi (22 km) of the creek (Nelson et al. 2009). Table 2-9 summarizes the results of the D. W. Alley & Associates (2008) tree canopy measurements.

Figure 2-25. Historical (1937) and current (2009) aerial photographs of riparian corridor conditions in the lower reach of Santa Rosa Creek and near the town of Cambria.

Table 2-9. Tree canopy closure in the lower 13 mi (20 km) of Santa Rosa Creek.[a]

Reach location (stream miles)	Tree canopy closure (percent)[b]				
	1994	1998	2002	2006	Average
0.5–2.9	n/a	33	42	27	34
2.9–3.4	n/a	40	54	42	45
3.4–4.2	44	36	53	42	44
4.2–7.9	44	32	33	24	33
7.9–9.6	57	34	55	44	48
9.6–10.1	72	63	67	58	65
10.1–11.2	63	63	77	67	68
11.2–11.5	52	70	80	85[c]	72
11.5–12.4	59	71	77	70	69
12.4–13.0	59	70	74	68	68
Average	56	51	61	53	

[a] Source: D. W. Alley & Associates (2008). Values are estimated from Figure A18 and correspond with values reported in the text, with the exception of reaches 0b and 2 in 2002. The text reports these values as 61 and 54 percent, respectively.
[b] Measurements were taken in the fall and are estimated to be between 5 and 10 percent lower than during summer due to the onset of leaf-fall (D. W. Alley & Associates 2008).
[c] The Reach 5 sampling site was relocated into the upper portion of Reach 4 in 2006 (D. W. Alley & Associates 2008).

Tree canopy closure ranged from a low of 24% between stream miles 4.2–7.9 to a high of 85% between stream miles 11.2–11.5 (both in 2006), and varied by both reach and year (Table 2-9). The lower 8 mi (12 km) of the creek (reaches 0a–2), where the channel is widest, had consistently lower ranges and average canopy closure than in the upper reaches (Table 2-9). This is to be expected since higher levels of canopy closure are easier to maintain across narrower channels. This same pattern was observed by CDFG, who recorded canopy closures between 17% and 46% in the lower 8 mi (12 km) of the creek, and 23% to 57% in the upper 6 mi (9 km) (Nelson et al. 2009).

The lower 10 mi (16 km) of the creek experienced a decline in canopy closure between 1994 and 1998 in response to the March 1995 flood. D. W. Alley & Associates (2008) report that "[t]he entire riparian corridor, with all of its trees, was washed away for miles in the lower valley during that one storm flow. Many tree-less vertical banks were left afterwards, even in the straight-aways." Conversely, the canopy closure in the upper three reaches increased by approximately 10% between 1994 and 1998. By 2002, canopy closure had recovered to at least 1994-levels in most of the lower reaches. The high-flow event of 2005, which was a particularly wet year, likely contributed to the decline in canopy closure experienced in all reaches between 2002 and 2006.

The difference in canopy closure between the lower and upper reaches suggests that riparian vegetation is more effective at moderating stream temperatures in the upper reaches. This is demonstrated by the generally lower water temperature measured in the upper watershed by CDFG (see Section 2.8.1 above). The variation in canopy closure over the years, which appears to be driven largely by high-flow events, implies that the ability of riparian vegetation to shade the channel and effectively moderate stream temperatures also varies over time. In the years immediately following a scouring high-flow event, riparian vegetation is likely less effective at moderating stream temperatures and providing other ecosystem services, regaining its effectiveness as it re-grows. The typically more pronounced decline in canopy closure in the lower reaches of the creek following high-flow events further limits the ability of riparian vegetation to moderate stream temperatures in these reaches.

2.10 Wildlife

The diversity of vegetation types, as well as aquatic environments, in the Santa Rosa Creek watershed support a wide variety of habitat for a number of fish and wildlife species. TLCSLOC (2010) and Fiscalini Ranch Preserve final Master Environmental Impact Report (Morro Group 2009) both summarize the wildlife species that have been observed or are likely to occur in the habitat types found throughout the watershed. As the focal species of this watershed management plan, steelhead life history, habitat requirements, and population in the Santa Rosa Creek watershed is the primary focus of this section. In addition, this section summarizes other special-status species that occur in the watershed, with an emphasis on those species whose life history, habitat requirements, and population trends provide further insight into watershed conditions and the development of appropriate management and restoration action, as well as documented non-native invasive species.

2.10.1 Steelhead

Steelhead (*Oncorhynchus mykiss irideus*) found in the Santa Rosa Creek watershed belong to the South-Central California Coast Distinct Population Segment (DPS), which includes most streams in Monterey, San Benito, Santa Clara, Santa Cruz, and San Luis Obispo counties between the Pajaro (inclusive) and Santa Maria (exclusive) rivers (NMFS 1997, 2006). This DPS is listed as threatened under the federal Endangered Species Act (NMFS 1997, 2006), and is a CDFG species of special concern. The life history of south-central California coast steelhead and their population trends in Santa Rosa Creek are described below. As the focal species of this watershed management plan, factors limiting steelhead in the watershed are discussed in detail in Section 3.

2.10.1.1 Life history

Steelhead is the term commonly used for the anadromous life history form of *O. mykiss*, and rainbow trout is the term for the resident life history. Both steelhead and rainbow trout are expressed within the Santa Rosa Creek watershed (Nelson et al. 2009), although detailed information on the relative proportion of each life history type is not available. The relationship between anadromous and resident life history forms of this species is the subject of ongoing research. The two forms are capable of interbreeding and current evidence suggests that, under some conditions, either life history form can produce offspring that exhibit the alternate form (i.e., resident rainbow trout can produce anadromous progeny and vice-versa) (Burgner et al. 1992, Donohoe et al. 2008, Zimmerman et al. 2009), although in some watersheds the two life histories are distinct (e.g., Pearse et al. 2009).

Steelhead return to spawn in their natal stream, usually in their third or fourth year of life, with males typically returning to fresh water earlier than females (Shapovalov and Taft 1954, Behnke 1992). Adult steelhead are known to stray from their natal streams to spawn in nearby streams and, in more hydrologically variable streams of the central coast such as Santa Rosa Creek, straying is often more prevalent (Clemento et al. 2009, Pearse et al. 2009). Based on variability in life history timing, steelhead are broadly categorized into winter and summer reproductive ecotypes. Only the winter ecotype (winter-run) occurs in Santa Rosa Creek. Winter-run steelhead generally enter spawning streams from late fall through spring as sexually mature adults, and spawn in late winter or spring (Shapovalov and Taft 1954, Behnke 1992, Busby et al. 1996). Little data on steelhead spawning time exist for Santa Rosa Creek, although both spawning time and distribution within the watershed appear to be related to time and duration of sandbar opening at the Santa Rosa Creek lagoon and winter discharge (D. W. Alley & Associates 2008, Nelson et

al. 2009). Peak spawning time for other steelhead populations in the South-Central California Coast ESU is generally between January and March (Busby et al. 1996).

Female steelhead construct redds in suitable gravels, often in pool tailouts, or in isolated gravel patches in cobble and boulder dominated streams (McEwan and Jackson 1996). Eggs incubate in redds for 3–14 weeks, depending on water temperatures (Shapovalov and Taft 1954, Moyle 2002). After hatching, alevins remain in the gravel for an additional two–five weeks while absorbing their yolk sacs, and then emerge in spring or early summer (Moyle 2002). After emergence in late-spring and summer, steelhead fry move to shallow-water, low-velocity habitat, such as stream margins and low-gradient riffles, and forage in open areas lacking instream cover (Hartman 1965, Fontaine 1988). As fry grow and improve their swimming abilities in the late summer and fall, they increasingly use areas with cover and show a preference for higher velocity, deeper mid-channel areas near the thalweg (the deepest part of the channel) (Hartman 1965, Everest and Chapman 1972, Fontaine 1988). Juvenile steelhead occupy a wide range of habitats, using deep pools as well as higher-velocity riffle and run habitat (Bisson et al. 1982, Bisson et al. 1988). During periods of low temperatures and high flows that occur in winter months, steelhead prefer low-velocity pool habitat with large rocky substrate or woody debris for cover (Hartman 1965, Raleigh et al. 1984, Fontaine 1988).

Juvenile[6] steelhead in northern and central California typically spend one to two years in freshwater prior to smolting[7] and outmigration to the ocean (Shapovalov and Taft 1954). The duration of time they spend in fresh water appears to be related to growth rate, with larger, faster-growing members of a cohort smolting earlier (Hayes et al. 2008). Depending partly on growing conditions in their rearing habitat, steelhead may migrate downstream to estuaries as young-of-the-year (YOY) or may rear in streams for up to four years before outmigrating to the estuary and ocean (Shapovalov and Taft 1954). Some steelhead in the lower 8 mi of Santa Rosa Creek likely require only one year of growth before reaching smolt size (approximately 6–7 in [150–180 mm]), whereas most fish above stream mile 8 typically require two years depending on availability of food and streamflow (D. W. Alley & Associates 2008). Age data from scale analysis and corresponding length data from individuals collected in the lower 8 mi of Santa Rosa Creek indicate that many individuals reach 4–5 in (120–140 mm) fork length[8] by their first fall (D. W. Alley & Associates 2008).

There is very little data describing juvenile steelhead life history strategies expressed in Santa Rosa Creek. Limited outmigrant trapping in Santa Rosa Creek suggests some individuals rear in upstream reaches before outmigrating as smolt, and some migrate to the lower reaches and lagoon at smaller sizes/younger ages (D. W. Alley & Associates 2008, Nelson et al. 2009). A portion of Santa Rosa Creek juvenile steelhead appear to have historically reared in the lagoon prior to outmigration (Puckett 1970, as cited in Rathbun et al. 1991), and recent evidence suggests some individuals likely still do in some years (Nelson et al. 2009, Alley and Sherman 2006, D. W. Alley & Associates 2008). During summer and fall sampling in 2004, Alley and Sherman (2006) captured 101 and 69 juvenile steelhead (varying in size from approximately 1–4 in [35–94 mm]

[6] In this report juvenile steelhead refers to both young-of-the-year (YOY) and age 1+/2+, unless indicated separately. YOY are age 0+ individuals less than one year old that hatched the previous spring or early-summer and are the offspring of adults that spawned the previous winter or early-spring. Age 1+/2+ refers to all pre-smolt juveniles one year old or older. This report presents age-class-specific juvenile data from D. W. Alley & Associates (2008), who assigned age-classes based on site-specific divisions in the frequency distribution of steelhead standard-lengths (SL). Based on this sampling, YOY are likely to be between 3 and 6 months old, and age 1+/2+ are likely between 1.25 and 2.5 years old.

[7] Smolts are juvenile steelhead migrating to the ocean (i.e., smolting) that exhibiting silver coloration and have no parr marks.

[8] Fork length is measured from the tip of the snout to the fork, or middle, of the caudal (tail) fin

standard length[9]), respectively between Shamel Park and Windsor Bridge. Available water quality data also suggests that, at least in some years, conditions are suitable for steelhead rearing in the lagoon (see Section 3.5). In nearby San Luis Obispo Creek, many YOY steelhead that hatch in upper tributaries and reaches migrate downstream and rear in lower mainstem reaches prior to entering the ocean (Spina et al. 2005).

Smolt downstream migration in Santa Rosa Creek typically occurs from March through early June (D. W. Alley & Associates 2008). Trapping at Santa Rosa Creek stream mile 0.35 in 2005 revealed a peak in smolt capture from mid to late April (Nelson et al. 2009), which is consistent with that documented in nearby San Luis Obispo Creek (Spina et al. 2005). Steelhead exhibiting smolt coloration ranged from approximately 5–10 in (130–250 mm) fork length, with 6–7 in (150–180 mm) fork length being most common (Nelson et al. 2009).

2.10.1.2 Distribution and status

Annual estimates of adult escapement, the number of adults returning to spawn, are arguably the best measure of steelhead population trends (Gallagher and Gallagher 2005). Unfortunately, no actual adult steelhead escapement data are available for Santa Rosa Creek. Information on the historical adult steelhead population abundance in Santa Rosa Creek is largely anecdotal, but all available evidence points towards a decline. A study from 1969–1970 indicated that the adult steelhead run in the creek was approximately 600 individuals (Seldon 1972, as cited in Becker and Reining 2008). Based on CDFG unpublished reports and field logs, Rathbun et al. (1991) reported that steelhead were “abundant” in the Santa Rosa Creek drainage as recently as the early 1980's, but provided no adult population estimate. However, anecdotal fishermen reports indicated declines in the numbers of adult fish entering the creek between 1987 and 1991 (Rathbun et al. 1991). From 1988–1991, CDFG received only a few reports of spawning adults, and no steelhead were seen during a survey of the lower 2 miles of the creek in mid-July 1991 (Rathbun et al. 1991, Titus et al. 2006).

The apparent decline of the adult steelhead population is supported by more quantified juvenile population data. In 1972 the total juvenile population was estimate to be over 60,000 fish (Bailey 1973, as cited in Nelson 1994). An apparent population crash occurred between 1972 and 1978, when the juvenile population was estimated to be less than 10,000 (Knable 1978, as cited in Nelson 1994). The juvenile population in 1993 remained at just over 10,000 individuals (Nelson 1994). More recent population estimates (1998–2006) reported by D. W. Alley & Associates (2008), indicate an apparent rebound, with the juvenile population ranging from approximately 25,000 to 65,000. However, the different methodology used for these recent estimates makes it difficult to accurately compare them with the older estimates (Titus et al. 2006). Moreover, between 1998 and 2006 the abundance of both age 0+, also referred to as young-of-the-year (YOY), and age 1+/2+ juvenile steelhead in Santa Rosa Creek significantly declined (D. W. Alley & Associates 2008) (Figures 2-26 and 2-27).

[9] Standard length is measured from the tip of the snout to the anterior edge of the caudal fin (excludes caudal fin).

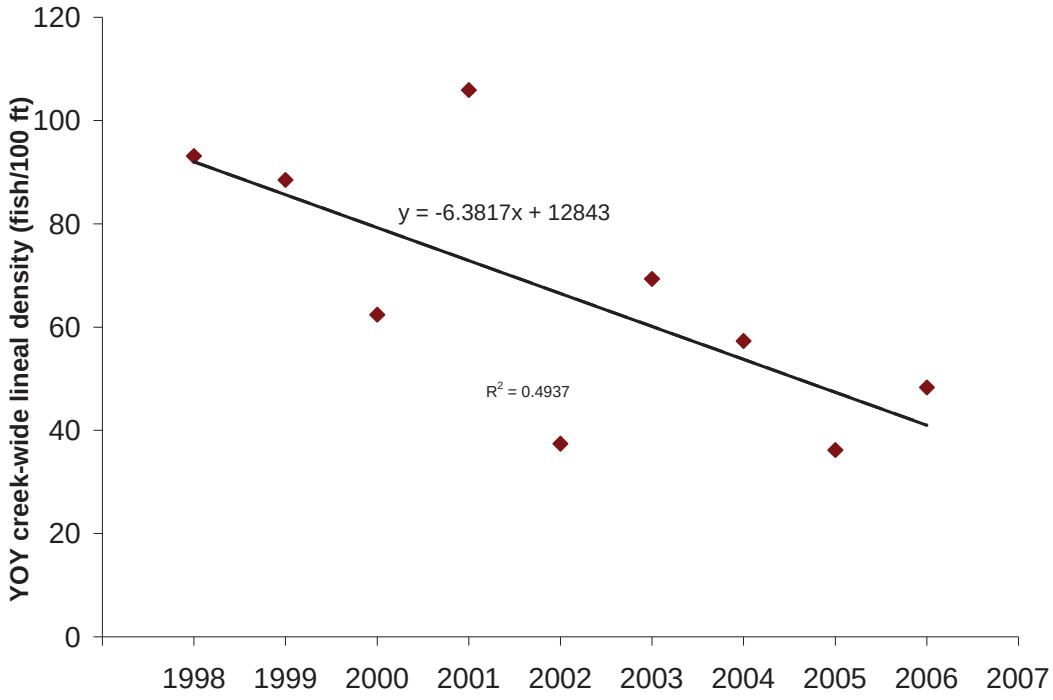

Figure 2-26. Lineal density (fish/100 ft) of YOY steelhead in Santa Rosa Creek from 1998 to 2006 (r^2 = 0.4937; P = 0.0348; n = 9). Data source: D. W. Alley and Associates (2007, Table 25a).

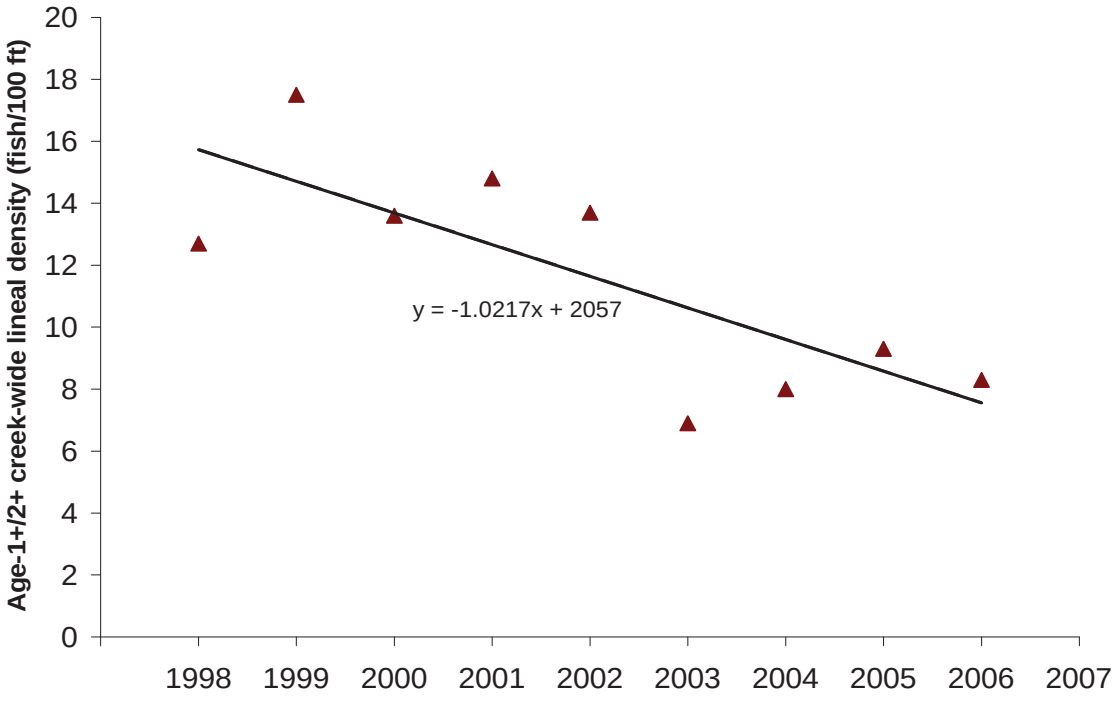

Figure 2-27. Lineal density (fish/100 ft) of age-1+/2+ steelhead in Santa Rosa Creek from 1998 to 2006 (r^2 = 0.592; P = 0.0154; n = 9). Data source: D. W. Alley & Associates (2007, Table 25a).

Juvenile steelhead densities are consistently higher in the upper reaches (approximately stream miles 8–13) than in the middle and lower reaches (approximately stream miles 0–8) of Santa Rosa Creek (D. W. Alley & Associates 2008, Nelson et al. 2009) (Figures 2-28 and 2-29).[10] The generally higher densities in the upper reaches suggest that a greater number of steelhead spawned there, that food availability and habitat quality are higher (and thus capable of supporting higher densities of fish), and/or that embryo and/or juvenile survival was higher in these reaches than in the lower watershed. In addition, the upper reaches are more likely to support some level of resident rainbow trout production due to water quality and habitat features, although this cannot be ascertained based on existing information. Habitat conditions vary considerably between the reaches, with the upper reaches generally containing larger substrates, less fine sediment, deeper pools, lower summer base flows, and more stream shading due to higher percentage of canopy closure, than the middle and lower reaches, which run through a marine terrace and are lower gradient and less confined (D. W. Alley & Associates 2008, Nelson et al. 2009).

Using average densities of juvenile steelhead from previous monitoring results, Titus et al. (2006) documented a statistically significant shift in the use between the upper (approximately stream miles 8–13) and lower reaches (approximately stream miles 0–8) over a 23-year period, with increasing use of the upper creek and decreasing use of the lower creek. These results suggest that the degraded physical habitat and reduced instream flows in the lower creek (see discussions in Section 3) have progressively rendered this area less and less suitable for rearing juveniles.

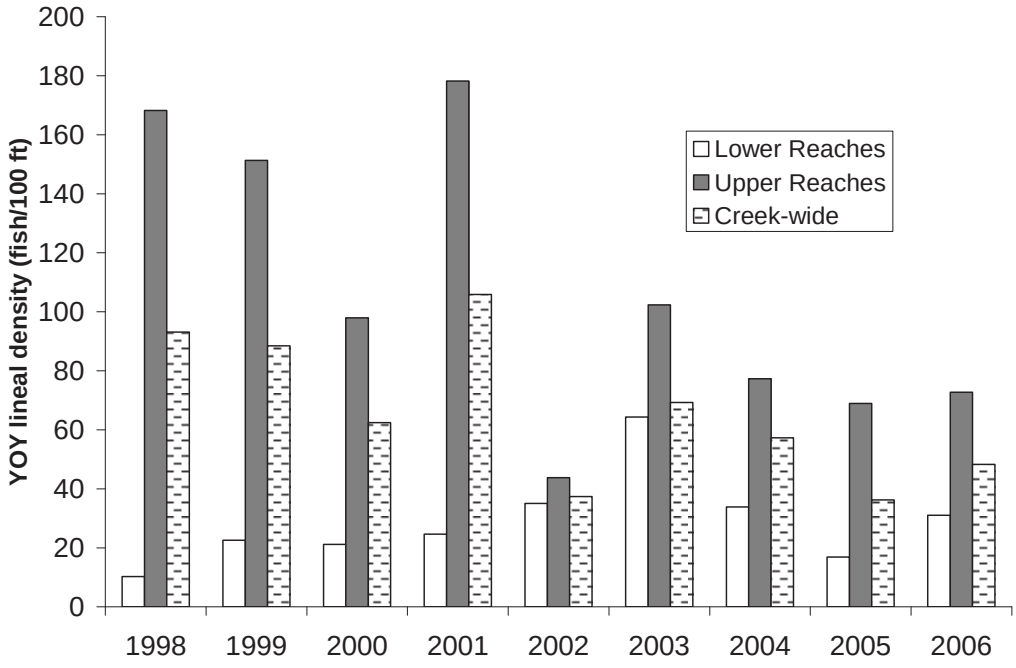

Figure 2-28. Mean lineal density of YOY steelhead at sample sites in the lower reaches (stream miles 0–8), upper reaches (stream miles 8–13), and creek-wide from 1998–2006. Data source: D. W. Alley & Associates (2007, Tables 26a and 26b).

[10] D. W. Alley & Associates (2008) and Nelson et al. (2009) used different reach delineations than those used and described previously in this document. These reports delineated lower reaches, also referred to as lower valley, from stream mile 0 to 8, and upper reaches, also referred to as upper canyon, from stream mile 8 to 13. These reach delineations are used when presenting data from D. W. Alley and Associates (2008) and Nelson et al. (2009).

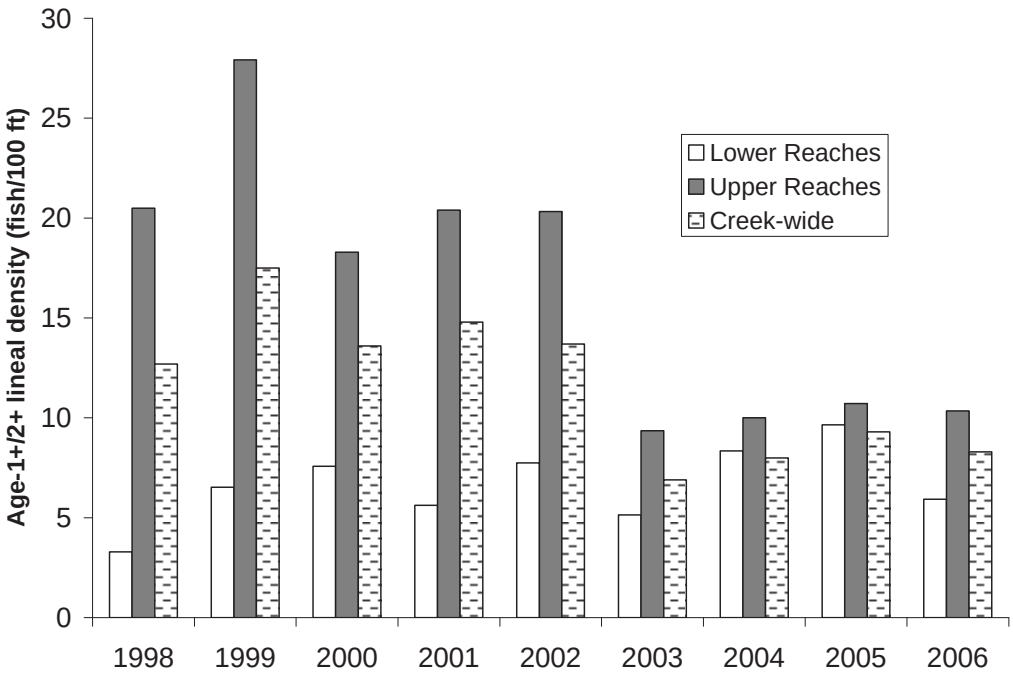

Figure 2-29. Mean lineal density of 1+/2+ steelhead at sample sites in the lower reaches (stream miles 0–8), upper reaches (stream miles 8–13), and creek-wide from 1998–2006. Data source: D. W. Alley & Associates (2007, Tables 26a and 26b).

Despite the evident decline in steelhead population since historical levels, compared to most other watersheds with populations in the DPS, Santa Rosa Creek contains a relatively high quantity of suitable spawning habitat and relatively high densities of juvenile steelhead have been observed in recent years (D. W. Alley & Associates 2008). For this reason, habitat restoration and continued monitoring of Santa Rosa Creek's steelhead population is considered important for the recovery of the DPS (NMFS 2007, CDFG 2010).

2.10.2 Other rare species

In addition to steelhead, TLCSLOC, Cambria Forest Management Plan, and Fiscalini Ranch Preserve final Master EIR all identified special-status wildlife species—those listed as threatened or endangered under either the federal or state Endangered Species Acts, or as a species of special concern (SC) by CDFG—with the potential to occur in the watershed (Cambria Forest Committee 2002, Morro Group 2009, TLCSLOC 2010). Of these, the following have been observed in the watershed (Rathbun et al. 1991, Nelson et al. 2009, D. W. Alley & Associates 2008, Morro Group 2009):

- Pacific (previously southwestern) pond turtle (*Actinemys marmorata*; SC)
- monarch butterfly (*Danaus plexippus*; CNDDB vulnerable species)
- tidewater goby (*Eucyclogobius newberryi*; federally endangered and SC)
- Monterey dusky-footed (Santa Lucia) woodrat (*Neotoma macrotis luciana*; SC)
- California red-legged frog (*Rana draytonii*; federally threatened and SC)
- American badger (*Taxidea taxus*; SC)
- two-striped gartersnake (*Thamnophis hammondii*; SC)

Pacific pond turtle, tidewater goby, California red-legged frog, and two-striped gartersnake have all been the subject of relatively recent surveys and reports in the Santa Rosa Creek watershed, as detailed below. The life history, habitat requirements, and population trends of these "umbrella species" provide additional insight, beyond that provided by steelhead, into the state of the watershed. In some cases, the habitat and life history requirements of these species are connected or overlap with those of steelhead and, as a result, appropriate management for steelhead is expected to benefit these species as well. In other cases, appropriate management for steelhead could conflict with the habitat and life history requirements of these other species. This section provides a brief overview of these species and their population trends in Santa Rosa Creek, and identifies potential synergies and/or conflict between these species and management for steelhead.

2.10.2.1 Pacific pond turtle

Pacific pond turtles inhabit fresh or brackish water characterized by areas of deep water, low flow velocities, moderate amounts of riparian vegetation, warm water and/or ample exposed basking sites, and underwater cover elements such as large woody debris and rocks (Jennings and Hayes 1994). In California, Pacific pond turtles are found from the Oregon border south to the border with Baja California, including the Central Valley and Sierra Nevada foothills, and along the Coast ranges (Stebbins 2003). The species has experienced population declines as conversion of wetland and riparian habitat to urban and agricultural use has accelerated (Jennings and Hayes 1994, Germano and Bury 2001). In addition, hatchlings and juveniles are vulnerable to predation by a variety of native and non-native mammals, birds, fish and amphibians (Moyle 1973, Holland 1985, both as cited in Rathbun et al. 1991).

Along major rivers, Pacific pond turtles are often concentrated in side channel and backwater areas. Turtles may move to off-channel habitats, such as oxbows, during periods of high flows (Holland 1994). While highly aquatic, Pacific pond turtles also spend time on land basking, over-wintering, nesting, and to seek refuge/cover, up to a reported 0.3–0.6 mi (0.5–1 km) away from aquatic habitats (Rathbun et al. 1992, Holland 1994, Reese and Welsh 1997, Rathbun et al. 2002). Egg-laying sites vary from sandy shoreline to forest soil types, though are generally located in grassy meadows, away from trees and shrubs (Rathbun et al. 1992, Holland 1994, Rathbun et al. 2002), with canopy cover commonly less than about 10% (Reese 1996). In an 8-year study of several creeks just north of Santa Rosa Creek, Pacific pond turtles left the drying creek beds in late summer for nearby woodland and coastal sage scrub habitat, and returned after winter floods, and females laid their eggs in sunny upland habitat, such as grazed pastures (Scott and Rathbun 2001, Rathbun et al. 2002).

Surveys of lower Santa Rosa Creek in the late 1970s consistently observed Pacific pond turtles hauled-out on logs in the lower end of the seasonal lagoon (D. Holland, unpubl. data, as cited in Rathbun et al. 1991). Since 1986, however, observations of Pacific pond turtles have decreased, and only two to three individuals were recorded downstream of the Highway 1 Bridge in 1991 (Rathbun et al. 1991). At least one Pacific pond turtle was captured in the lower 14 mi (22 km) of Santa Rosa Creek during CDFG's steelhead surveys in 2005 (Nelson et al. 2009). Rathbun et al. (1991) attribute this apparent decline to insufficient instream flows resulting from a combination of below-average precipitation that year and groundwater pumping in the lower reaches of the creek.

In general, management actions to enhance steelhead habitat should also benefit Pacific pond turtles. For example, actions to increase instream flow, enhance the riparian corridor, reduce fine sediment delivery to channels, and provide instream woody debris should improve aquatic habitat

conditions for Pacific pond turtle. However, the conservation of upland scrub and grassland habitat adjacent to the creek is equally important for egg-laying, refuge, and basking habitat.

2.10.2.2 Tidewater goby

Tidewater goby is a small fish that inhabits coastal lagoons, marshes, estuaries, and lower stream reaches along the California coast from Del Norte County to San Diego County (Swift et al. 1989, Moyle 2002, USFWS 2005). The fish still occurs within this range, but at over half of the sites within the distribution, populations have been extirpated or are extremely small with uncertain long-term persistence (USFWS 2005). The decline in this species resulted in it being listed as federally endangered in 1994 (USFWS 1994). Tidewater gobies are an important part of estuarine food webs because they provide prey for larger fish, aquatic snakes, and piscivorous birds (Swenson and McCray 1996). Tidewater gobies are threatened by changes in water quality, degradation and loss of winter and summer habitat due to urbanization and sandbar breaching, and predation from invasive species.

During reproduction/spawning, juvenile, and adult life stages, tidewater goby appear to prefer shallow depths (20–100 cm [8–39 in]) near emergent vegetation at the fringe of large estuaries and within lagoon and tidal slough systems, though possibly deeper since most previous surveys did not effectively sample in deeper waters (Stillwater Sciences 2006a).

Tidewater gobies were documented as abundant in the Santa Rosa Creek lagoon in 1977, but subsequent surveys in the early to late 1980s documented only small numbers (Swift 1977, 1981, and Dudley 1988, as cited in Rathbun et al. 1991). As with other species in the lower creek, Rathbun et al. (1991) attributed this decline to a lack of instream flow from primarily agricultural and urban water use. D. W. Alley & Associates surveyed tidewater goby in Santa Rosa Creek lagoon from 1995 to 2007 and documented highly variable abundance (Alley and Sherman 2006, D. W. Alley & Associates 2008).

Habitat restoration may be mutually beneficial to steelhead and tidewater gobies. For example, enhancement of brackish marshes and lagoon habitat can increase steelhead rearing habitat while also providing year-round habitat for tidewater goby (Stillwater Sciences 2006a). However, the habitat requirements of the tidewater goby differ enough such that restoration for steelhead may not always be beneficial, and under some circumstances may be detrimental, to tidewater goby populations (Stillwater Sciences 2006a). Therefore, care must be taken when implementing actions to enhance steelhead habitat to minimize unintended consequences on tidewater goby habitat. Accurate predictions of the effect of restoration on both water depths and salinity dynamics are crucial in determining the long-term effect of restoration on tidewater goby habitat quality and extent (Stillwater Sciences 2006a).

2.10.2.3 California red-legged frog

California red-legged frogs are found in ephemeral or permanent bodies of water, including wetlands, natural and artificial ponds and reservoirs, wet meadows, lakes, and low-gradient, slow-moving stream reaches with permanent pools, primarily in coastal drainages along California's central coast. The frog's range covers Mendocino County to Baja California, with isolated remnant populations occurring in the Sierra foothills, from sea level to approximately 8,000 ft (2,440 m) (Stebbins 2003, Shaffer et al. 2004). They are considered extirpated from the foothills of the Sierra San Pedro Martir, the coastal plain of Baja California Norte, and the Central Valley region, which represents an approximate 70% reduction of its historical range (CDFG 2009, USFWS 2002). California red-legged frog populations are threatened within their remaining

range by a variety of human-influenced impacts, including urban encroachment, altered hydrological regimes that are not suitable for their life history needs, introduction of exotic predators and competitors, contaminants including pesticides and fertilizers, and habitat fragmentation (USFWS 2002). It is a threatened species under the federal Endangered Species Act (USFWS 1996) and a California species of special concern.

California red-legged frog

California red-legged frog habitat is generally characterized by still or slow-moving water with deep pools (usually at least 2 ft [0.7 m], though frogs have been known to breed in shallower pools) and emergent and overhanging vegetation, usually cattails, rushes, or willows (Jennings and Hayes 1994). Although some adults may remain resident year-round at favorable breeding sites, others may disperse overland up to a mile or more (Fellers and Kleeman 2007). Movements may be along riparian corridors, but some individuals move directly from one site to another without apparent regard for topography or watershed corridors (Bulger et al. 2003). California red-legged frogs sometimes enter a dormant state during summer or in dry weather, finding cover in small mammal burrows, moist leaf litter, root wads, or cracks in the soil. California red-legged frog populations are likely to persist where multiple breeding and non-breeding aquatic areas are embedded within a matrix of upland dispersal habitat (USFWS 2002, Fellers and Kleeman 2007). In the study of several creeks north of Santa Rosa Creek, high spring flows were found to inhibit California red-legged frog breeding and eliminate egg masses in some creeks in some years (Scott and Rathbun 2001). In general frogs were always found in or very near water, but could be found farther upland in wet winters. Overhanging willow branches, bulrush/ cattails, exposed tree roots, and upland thickets were the most common cover types used by frogs during the study (Scott and Rathbun 2001).

Annual herpetological surveys of lower Santa Rosa Creek from the mid-1970s to 1989 consistently documented California red-legged frogs, but in decreasing numbers (Rathbun et al. 1991). In 1991, only two red-legged frogs—one dead—were observed in the creek between the Windsor Street bridge and Highway 1 bridge (Rathbun et al. 1991). An unspecified number of California red-legged frogs were captured in the lower 14 mi (22 km) of Santa Rosa Creek during CDFG's steelhead surveys in 2005 (Nelson et al. 2009). Rathbun et al. (1991) identified insufficient instream flow in lower Santa Rosa Creek, as a result of agricultural and urban water use, and a lack of adequate cover as the primary causes of the decline in red-legged frogs in this area.

In general, management actions to enhance steelhead habitat should also benefit California red-legged frogs, including increasing instream flows, enhancing riparian habitat, reducing fine sediment delivery to channels, providing instream woody debris and undercut banks for cover, and managing for non-native species (USFWS 2002). For California red-legged frog, it is also important to provide adequate connectivity between breeding, non-breeding, and dispersal habitats (Fellers and Kleeman 2007), as well as to conserve a well-distributed array of natural habitat elements in terrestrial areas upland from occupied aquatic sites (Bulger et al. 2003). Habitat for early life stages of steelhead tend to be similar for California red-legged frogs tadpoles, including low-velocity areas near streambanks.

2.10.2.4 Two-striped garter snake

The two-striped garter snake is generally found around pools, creeks, cattle tanks, and other water sources along the California coast from Monterey County to northern Baja California (Stebbins 2003). Two-striped garter snakes are threatened by a loss of wetland habitat, which has contributed to a reduction in their range. It is currently a California species of special concern.

Although generally considered an aquatic species, preferred retreat habitat is terrestrial, such as mammal burrows, crevices, and surface objects (Rathbun et al. 1993). Juveniles and adults feed primarily on small fish, fish eggs, tadpoles, frog metamorphs, and small invertebrates (Jennings and Hayes 1994). A study of several creeks just north of Santa Rosa Creek found that female two-striped garter snakes spent most of the year in various terrestrial habitats, either on the surface, under surface objects, or in animal burrows (Scott and Rathbun 2001). In the water, snakes were most often found among aquatic vegetation, cattails, bulrushes, and overhanging willow branches. Upland, snakes were often associated with grassy areas and small mammal borrows (Scott and Rathbun 2001).

Numerous two-striped garter snakes were observed in lower Santa Rosa Creek during surveys in the late 1970s, but none were observed in subsequent surveys (Rathbun et al. 1991). As with other aquatic species in the lower creek, Rathbun et al. (1991) attributed this decline to a lack of instream flow from primarily agricultural and urban water use, which is likely correlated with a decrease in aquatic prey species, such as small fish and frogs/tadpoles.

In general, management actions to enhance steelhead habitat should also benefit two-striped garter snakes. Primarily, actions to increase instream flow, enhance the riparian corridor, and reduce fine sediment delivery to streams should improve aquatic habitat conditions for two-striped garter snake by increasing their prey base. However, the conservation of upland habitats adjacent to the creek is equally important for refuge and basking.

2.10.3 Non-native, invasive wildlife species

While most non-native species are not particularly invasive or detrimental, some have no natural controls in their new environmental and are able to spread unchecked, causing significant and sometimes irreparable damage to native habitat and species. For example, non-native invasive species can prey on native species, out-compete native species for food and other resources, and/or degrade habitat for native species. While there has been no comprehensive survey for non-native invasive fish and wildlife species in the Santa Rosa Creek watershed, incidental observations during surveys for steelhead and other native species provide an indication of the primary non-native invasive species that occur in the watershed.

2.10.3.1 Aquatic species

Dr. Dan Holland (unpublished data, as cited in Rathbun et al. 1991), CDFG (Nelson 1994, Nelson et al. 2009), and D. W. Alley & Associates (2008) recorded the presence of several non-native aquatic species in creeks in the watershed. These include:

- brown bullhead catfish (*Ictalurus nebulosus*)
- green sunfish (*Lepomis cyanellus*)
- bluegill (*Lepomis macrochirus*)
- crayfish (*Pacifastacus leniusculus*)
- bullfrog (*Rana catesbeiana*)

Mosquitofish (*Gambusia affinis*) are also likely to occur in the creek and ponds in the watershed (G. Rathbun, pers. comm., 2010). Many of these non-native species have been documented to prey upon native species and are capable of continually dispersing into Santa Rosa Creek from the many stock ponds in the watershed. Preventing their further establishment and eradication has been identified as an important step in protecting native species populations in Santa Rosa Creek (Rathbun et al. 1991, D. W. Alley & Associates 2008, Nelson et al. 2009). Rathbun et al. (1991) implicated bullfrogs and bass in the extirpation of tidewater goby in nearby Old Creek (near the town of Cayucos) and noted that bluegill may be a serious predator of tidewater gobies and red-legged frog eggs in Santa Rosa Creek. Similarly, D. W. Alley & Associates (2008) identifies introduced non-native predators, such as centrarchids (bass family of fishes), bullfrog and possibly crayfish as one of the four major threats to tidewater goby in the watershed. In an assessment of steelhead habitat and limiting factors, Nelson et al. (2009) notes that while crayfish have been shown to consume salmonid eggs, the impact of their ubiquitous presence in Santa Rosa Creek is not understood and their eradication would be difficult at best. Nelson et al. (2009) were particularly disconcerted by the presence of bullfrogs and green sunfish, which can prey upon steelhead eggs and young-of-the-year, but are generally less common in small coastal streams like Santa Rosa Creek. They continued: “Given the warm water temperatures in the lower watershed both of these non-native species will thrive during the summer months. It is doubtful that the sunfish could withstand the higher winter flows, but the adult bullfrogs will move to higher ground during these flow events, re-occupying the creek when flows subside.”

There have been no documented reports of Asian clam (*Corbicula fluminea*), a highly invasive aquatic invertebrate, in the Santa Rosa Creek watershed, but it has been documented in the Salinas River and in Lake Nacimiento by the USGS Nonindigenous Aquatic Species program (NAS 2010).

2.10.3.2 Terrestrial species

European starlings (*Sturnus vulgaris)* and brown-headed cowbirds (*Molothrus ater*) are both widespread non-native birds that can affect native bird populations and occur or are likely to occur in the Santa Rosa Creek watershed. European starlings are aggressive competitors for nest holes, often evicting native species, while brown-headed cowbirds are brood-parasites of many native bird species (i.e., they lay their eggs in the nests of native birds, who then raise the cowbird chicks often to the detriment of their own offspring) in riparian areas throughout California, especially those near agricultural lands. There have been no documented reports of brown-headed cowbirds in the Santa Rosa Creek watershed specifically, but high counts of the birds have consistently been recorded during the annual Christmas Day bird count in San Luis Obispo County (MCAS 2005, 2006). European starling populations appear, at least anecdotally, to be increasing in the watershed (R. Hawley, pers. comm., 2010).

Feral pigs (*Sus scrofa*) are known to occur and cause damage to creek channels and other areas in the watershed (S. Soto, pers. comm., 2010; G. Kendall, pers. comm., 2010; M. Smith, pers. comm., 2010). California’s feral pig population likely started in San Benito and Monterey counties with escaped domestic swine brought over by Mexican settlers, who commonly released swine to forage in woodlands (Groves and Di Castri 1991, Kreith 2007). Since then feral pigs have been deliberately (and illegally) relocated elsewhere in the state for hunting (Kreith 2007). In the Santa Rosa Creek watershed, wild Russian boars and sows were brought in for hunting in the 1930’s by a landowner to amuse his guests (D. Dunlap, pers. comm. 2010). Swine have the greatest reproductive capacity of all free-ranging, large mammals in the United States (Wood and Barrett 1979) and population expansion can occur rapidly. Feral pigs degrade ecosystems through predation and competitive impacts on native fauna, grazing on native plants, and physically

altering habitat by rooting. Rooting creates large, disturbed areas that can lead to extensive erosion, displace native species, facilitate invasion by non-native, invasive plant species (Barrett 1977), and contribute to fine sediment delivery to waterways. Feral pig disturbance causes several million dollars in damages to crops, fencing, roads and trails annually in California, and, between 2002 and 2006, for over $275,000 in damages in San Luis Obispo County alone. Feral pig is regulated as a big game mammal by CDFG. Hunting is believed to have thinned the feral pig population in the Santa Rosa Creek watershed dramatically compared with levels in the 1960s through 1980s, but the population appears to be increasing again in the upper watershed (S. Soto, pers. comm., 2010; D. Dunlop, pers. comm., 2010).

2.11 Critical Issues

There are several issues that are impairing or have the potential to affect ecological conditions in the Santa Rosa Creek watershed and make obvious focal points for restoration and management planning. These issues are summarized below and include water quantity, water quality, fine sediment, non-native invasive species, and changes in land use. Several of these issues feature prominently in the steelhead limiting factors analysis (Section 3), and recommendations to address them are included in Section 4.

2.11.1 Water quantity

While the Santa Rosa Creek watershed, due to its climate and setting, likely experienced very low and intermittent flows in the late summer and fall on occasion under historical conditions, groundwater pumping and riparian water diversions are removing water that would otherwise be available to the stream channel (see Section 2.6). Since the establishment of the San Simeon well field in 1979, groundwater extraction in the Santa Rosa Creek watershed by CCSD for municipal use has ranged from 0 to just over 200 acre-feet annually. Through the early 1990s, the amount of groundwater and surface water extracted by private entities was estimated to be approximately 3.5 times the amount pumped by the CCSD. The precise effects of groundwater pumping and water diversion on the volume of instream flow are not currently known, but there is general consensus among the resource scientists who have surveyed the watershed that low instream flows have contributed to the decline of several special-status aquatic species in the watershed (Rathbun et al. 1991, D. W. Alley & Associates 2008, Nelson et al. 2009).

Reduced instream flows are particularly problematic in the intermittent reach of the creek and in the lagoon. In the intermittent reach of the creek (see Figure 2-8), where surface flows readily percolate into the subsurface, reduced instream flows constrain, and may entirely eliminate, connectivity between upstream and downstream habitat. The mechanisms for water loss in this reach, and thus for restoring flows, are not currently well understood. In the lowest reaches of the creek and in the lagoon, reduced instream flows limit the extent of aquatic habitat and likely contribute to elevated stream temperatures and low DO levels in the lagoon.

2.11.2 Water quality

In general, water quality in the middle and upper reaches of Santa Rosa Creek is good: relatively low summer stream temperatures and a diverse assemblage of benthic macroinvertebrates that are indicative of high water quality are maintained. As one moves downstream, however, water quality becomes increasingly reduced. Water temperatures begin to increase, and occasionally exceed CCRWQCB water quality criteria for temperature in the summer, in the downstream portion of the middle reach, most likely as a result of limited riparian canopy cover in some areas

and low instream flows. Sites adjacent to the town of Cambria had the least diverse assemblages of benthic macroinvertebrates and exhibit generally poor water quality as a result of increased levels of urban runoff, riprap, concrete, and trash. Water quality criteria for temperature and DO are frequently exceeded in the lagoon, in part as a result of low instream flows.

Sediment samples downstream of the Oceanic Mine on Curti Creek, including several in the lagoon, indicate elevated levels of mercury in the watershed (Section 2.8.3). Mercury is delivered to the watershed primarily from the erosion of mercury-laden waste rock at the former mill site by Curti Creek. No actions have been implemented to control this delivery or remediate the mine or former mill site. While additional study is necessary to determine the extent of mercury bioaccumulation in the aquatic food chain, moderately elevated levels of methylmercury—the bioavailable form of mercury—were recently measured in the Santa Rosa Creek lagoon.

2.11.3 Fine sediment in the lower reaches

Historically, fine sediment production rates likely increased substantially during the late 1800s and early 1900s when land clearing activities initiated (e.g., logging, ranching, and urbanization). Changes in the rainfall-runoff dynamics caused by this land clearing created a flashier system that more effectively eroded previously stored sediment on the hillslopes creating numerous erosional features (e.g., gullies and landslides), and led to channel incision throughout the watershed, particularly in the middle reaches of Santa Rosa Creek and the middle and upper reaches of Perry and Green Valley creeks. Over time, the channel incision eventually drove the mass instability of channel banks, another significant source of fine sediment. Together, this increase in hillslope and bank erosion rates led to proportionally higher rates of fine sediment delivery (as opposed to coarse sediment delivery) to stream channels in the watershed.

During the past half century, high fine sediment production rates have been reduced for the following reasons: (1) land use activities and vegetation coverage remained largely unchanged; and (2) the supply of sediments stored on hillslopes is less available after significant volumes were previously evacuated. The number and size of gully and landslide features present in the early 20th century have not changed considerably in recent decades, further indicating that land use-induced erosion of the landscape has stabilized. Additionally, and perhaps more importantly, stored sediment in the Santa Rosa Creek channel bed is predominantly coarse-grained (fine gravels to coarse cobbles), with few accumulations of fine sediment in the middle and upper reaches. This signifies that present-day fine sediment yields to the channel, which are assumed to be greater than pre-settlement rates, are not overwhelming the transport capacity of the channel under the current flow regime. This ability of the channel to self-maintain a predominantly coarse-grained bed helps to provide suitable instream habitat. However, occurrences of bank erosion exacerbated by incised channel morphology, altered watershed hydrology, and road runoff continue to represent a significant fine sediment source that can limit habitat quantity and quality at the reach scale.

The downstream, low-gradient reaches of Perry and Green Valley creeks are very fine-grained indicating that these major tributaries transport a high fine-sediment load to the lower reaches of Santa Rosa Creek. In addition, stormwater runoff-related erosion from Cambria neighborhood roads and home lots may also contribute to fine sediment in the lower reaches of Santa Rosa Creek. While the much of this input of fine sediment is conveyed with relative ease out of the watershed, the instream habitat quantity and quality of lower Perry and Green Valley creeks are limited by their fine-grained channels and enough remains in the lower reaches of Santa Rosa Creek to embed coarser substrates (see Section 3 for additional details).

2.11.4 In-channel infrastructure

Culvert on Curti Creek

Although the two downstream-most barriers to fish migration and movement (i.e., Burton Street Bridge and Ferrasci Road crossing) have been corrected, close to 20 man-made (i.e., bridges and culverts) barriers have been identified in the watershed. Barriers that may impede access to potential steelhead spawning and rearing areas include several stream crossings on Perry and lower Green Valley creeks.

Streambank rip-rap placement in the lower reaches of Santa Rosa Creek may cause flow to be deflected back across the channel resulting in further erosion downstream and threatening downstream land and infrastructure. If continued, extensive rip-rap placement could cause channel incision, more rapid flows, channel bed armoring (i.e., coarse bed surface layer), and reduced topographic complexity of the channel bed resulting in significant reductions in habitat suitability for native aquatic organisms including salmonids.

2.11.5 Non-native invasive species

Stream surveys and other resource inventories have documented a variety of non-native invasive plant and animal species in the watershed. Several of these species are known predators of steelhead and other special-status aquatic species in the watershed, can alter and impair native habitat conditions, and/or have the ability to disperse and expand their distribution quickly. Relatively large infestations of some species, such as eucalyptus, cape ivy, crayfish, bullfrogs, and freshwater sunfishes, have already been reported. In addition, the currently limited distribution of some of the non-native invasive species documented in the watershed (e.g., arundo, pampas/jubata grass, and French broom) can quickly change since they are known to spread rapidly and can be difficult or problematic to control. For many non-native invasive species, early detection is important so that control measures can be undertaken before an infestation worsens and control becomes increasingly difficult.

2.11.6 Changes in land use

The subdivision of large parcels, population growth, and the proposed desalination plant all have important ramifications on the future condition of the Santa Rosa Creek watershed. In recent decades, fine sediment delivery to stream channels in the watershed has been reduced closer to pre-development levels primarily because land uses on high-yielding geomorphic landscape units have not changed over this time. The subdivision of large parcels is likely to result in land use changes in the smaller parcels. If these future land uses remove vegetation, change hillslope topography, or alter runoff patterns, there is the potential that gully and rill erosion could be reinitiated with a subsequent increase in fine sediment delivery to watershed stream channels. Retaining large parcels or otherwise conserving existing land uses, particularly in the upper watershed, could be a valuable tool in preventing the degradation of aquatic habitat throughout the watershed. In subdivided parcels, it will be important that land use changes are implemented in a way that reduces the potential for erosion and that associated increases in water demand are avoided.

The combination of San Luis Obispo County population growth and the proposed desalination plant to supplement the municipal water supply has the potential to increase the population and development in and around Cambria. This could further increase water demand and subsequently lead to impacts related to urban development that threaten aquatic habitat in the lower watershed (e.g., increased impervious surfaces, contaminated runoff, non-native invasive species introductions, and encroachment of floodplains and the riparian corridor). San Luis Obispo County's (2008) North Coast Plan restricts growth associated with any public works water supply project within the CCSD service area, stating: "[t]he maximum service capacity of the project will not induce growth inconsistent with the protection of coastal resources and public access and recreation opportunities," and that "[t]he project shall assure that CCSD water withdrawals from Santa Rosa and San Simeon Creeks will be sufficiently limited to protect: (1) adequate instream flows necessary to support sensitive species and other riparian/wetland habitats within the reach of the streams affected by CCSD pumping; (2) underlying groundwater aquifers; and (3) agricultural resources." Abiding by these restrictions by reducing groundwater pumping if the desalination plant is someday operational would minimize the potential effects of growth in Cambria on Santa Rosa Creek.

3 STEELHEAD LIMITING FACTORS ANALYSIS

The following limiting factors analysis describes seasonal and age class-specific habitat needs and discusses how habitat conditions in Santa Rosa Creek likely affect each steelhead freshwater life stage. The aim is to integrate the effects of habitat carrying capacity and density-independent mortality (i.e., sources of mortality such as water temperature or disease with effects that are not dependent on the density of the population) across the entire life cycle of steelhead to determine mechanisms regulating population growth. Determining the relative effect of each life stage on overall population dynamics then allows for the identification of the factors most limiting steelhead production in the watershed (i.e., limiting factors) (Section 3.6) and specific actions that can be taken to address these factors (Section 4).

A species' life history and available habitat are among the many factors that can influence the growth or decline of a population (i.e., population dynamics) (Figure 3-1). Individual growth rate, survival, outmigration size, outmigration timing, ocean survival, upstream migration, and spawning success can all influence population dynamics of the Santa Rosa Creek steelhead population. Central to this analysis of limiting factors, which draws primarily upon the recent monitoring work of CDFG (Nelson 1994, Nelson et al. 2009) and D. W. Alley & Associates (2007 and 2008), is that steelhead population dynamics in Santa Rosa Creek are defined by two major characteristics: (1) patterns of habitat use between the upper and lower reaches, and (2) annual variation in flow. As to the first point, most of the successful spawning and rearing of steelhead in Santa Rosa Creek occurs in the upper reaches of the watershed (upstream of stream mile 8), although individual growth rates in the lower reaches (downstream of stream mile 8) appear to be high. Secondly, nearly every pattern of steelhead distribution, habitat use, abundance, density, or growth within the watershed is related to significant annual variation in instream flow conditions (as influenced primarily by precipitation). The sections below summarize the current understanding of the Santa Rosa Creek steelhead population based on the information gathered to date, and describe preliminary hypotheses of the primary factors likely limiting steelhead production in the watershed.

Ideally this understanding of steelhead and limiting factors hypotheses will be tested through the recommendations in Section 4, such that preliminary hypotheses are accepted, rejected, or refined, based on new understanding of the system, and as new uncertainties are identified. The iterative process of hypothesis development, testing, and refinement provides an adaptive and efficient process for identifying restoration strategies and any additional priority studies for the conservation and support of steelhead.

3.1 Spawning Habitat

For anadromous steelhead populations (as well as other pacific salmon populations such as coho salmon), the average fecundity, the number of eggs in a female fish prior to spawning, is high relative to the amount of suitable juvenile rearing habitat usually available within a stream. Rather than being controlled by reproductive success, growth of anadromous populations tends to be limited by physical habitat constraints during the juvenile freshwater rearing stage. As described below this generally appears to be the case for Santa Rosa Creek as well, although spawning habitat quality in the lower reaches of Santa Rosa Creek, where fish can be restricted in dry winters, may become more limiting relative to juvenile habitat in some years.

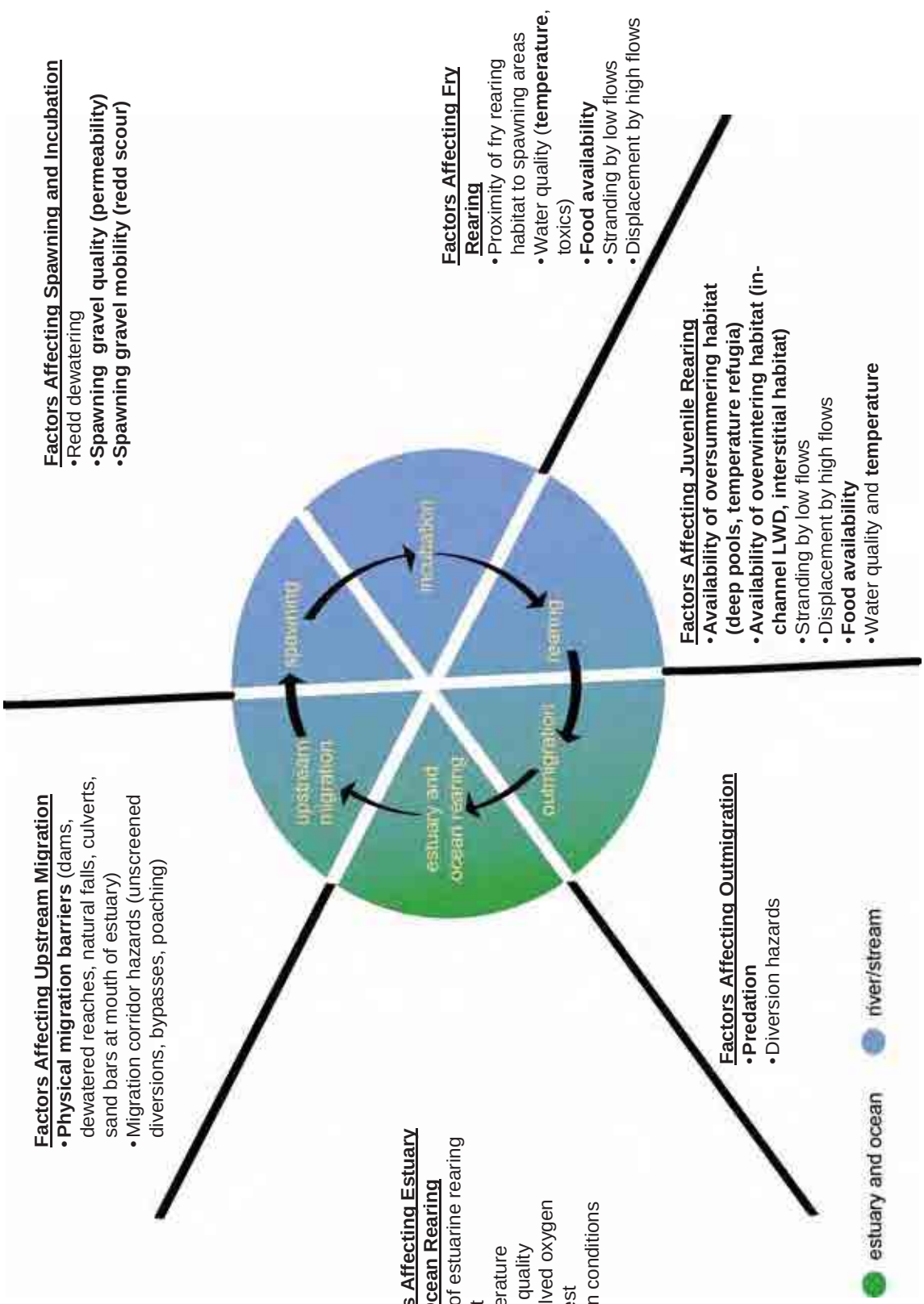

Figure 3-1. Steelhead life cycle with potential factors affecting each life stage.

3.1.1 Access to spawning habitat

CDFG surveys from the 1930s found no significant migration barriers to steelhead access in Santa Rosa Creek (Titus et al. 2006). Under current conditions several culverts and other man-made structures have been identified in the Santa Rosa Creek watershed that restrict the ability of migrating steelhead to access high quality upstream spawning habitat (see Section 2.7). Two of the furthest downstream barriers (Burton Street Bridge apron at stream mile 1.9 and Ferrasci Road crossing at stream mile 3.4) have recently been modified to allow fish passage under a wider range of flow conditions. Undersized and/or poorly placed culverts at road crossings likely limit steelhead access to potential spawning areas in Taylor and Curti creeks, and just as importantly, they disrupt the supply of coarse sediment and large woody debris that is necessary to create and maintain suitable rearing habitat (see Sections 3.2 and 3.3 below).

Nearly every road crossing in the Perry/Green Valley Creek sub-watershed has been identified as a potential fish passage barrier, but none have been assessed to determine if, why, or when a barrier to fish movement occurs (CalFish 2009; see Section 2.7). It is not known how often or in what capacity steelhead use reaches of the Perry/Green Valley Creek sub-watershed, or what condition those reaches are in (Nelson et al. 2009, Appendix A). Determining the potential for steelhead to access this sub-watershed would be an important first step towards understanding the relative importance of this sub-watershed for steelhead.

Low instream flows, which likely occurred naturally in drier years but are now exacerbated by groundwater pumping and water diversions, can also present barriers to fish movement on Santa Rosa Creek, particularly in the intermittent middle reaches (see Figure 2-8). Based on comparison of available flow data from the Main Street Bridge gauge (see Section 2.6) and steelhead passage requirements on lower Santa Rosa Creek (D. W. Alley & Associates 1993), it appears that when steelhead migration is initiated (as early as December) flows are typically adequate to allow migration, but that these flows are not continuously maintained throughout the entire upstream adult and downstream juvenile migration periods. It has also been suggested that in dry winters adult entrance into the lagoon and passage over shallow riffles can be constrained (Nelson 1994, Nelson et al. 2009, D. W. Alley & Associates 2007). Nelson et al. (2009) report that over one-half of the high-quality spawning locations are located upstream of stream mile 8, downstream of which the creek typically goes seasonally dry. During drier winters, this dry reach may significantly delay or prevent adult steelhead from accessing, and smolts from emigrating from, the upper reaches (Nelson et al. 2009).

Analyses of YOY steelhead capture data suggest that rainfall affects adult passage into the upper reaches of Santa Rosa Creek and drives the distribution of spawning and resulting YOY distribution (D. W. Alley & Associates 2007). Relative to the lower reaches, fall YOY densities were generally higher in the upper reaches in years with higher rainfall amounts during the previous year (D. W. Alley & Associates 2007, Nelson et al. 2009). Furthermore, the ratio of YOY steelhead densities in the upper reaches to lower reaches was positively correlated with rainfall in the preceding water year (Figure 3-2). These analyses suggest that during years with higher rainfall, such as 2005, a higher percentage of adults can migrate through the lagoon and lower reaches to access preferred spawning areas in the upper reaches (where greater numbers of YOY steelhead are produced), although the analyses did not specify whether this improved access is a result of longer sandbar breaching, the elimination of dry riffles, and/or improved flow conditions through or over structural barriers. A prolonged drought may prevent adult steelhead access to spawning grounds in the upper watershed for several consecutive years (Nelson et al. 2009).

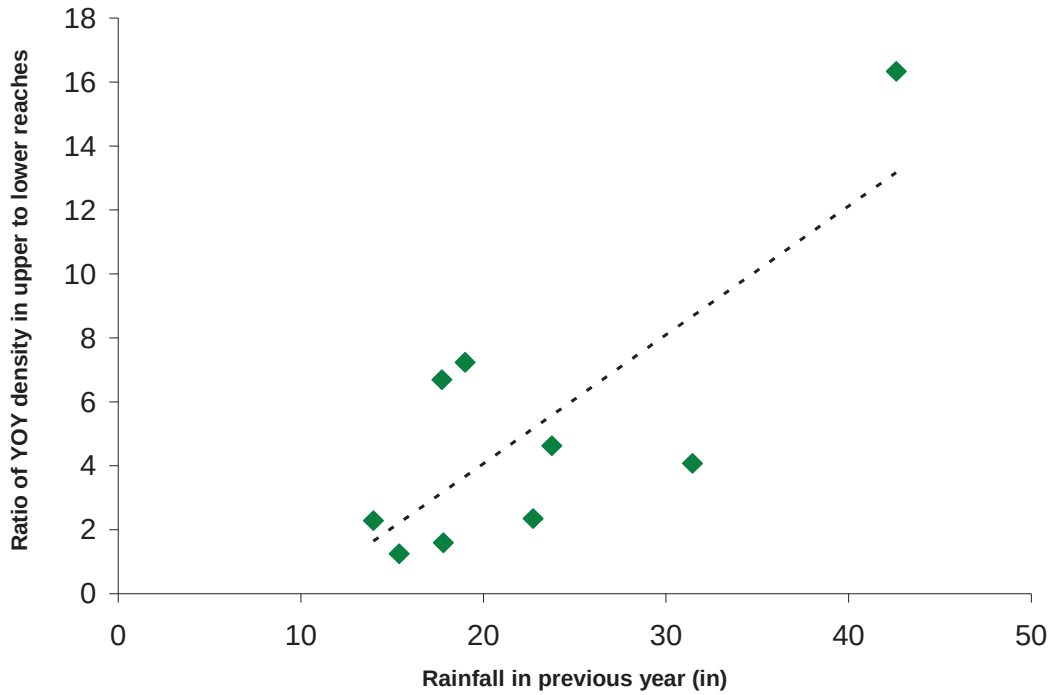

Figure 3-2. Ratio of YOY steelhead lineal density in upper to lower reaches versus rainfall in the previous water year (r^2 = 0.61; P = 0.0130; n = 9). Data sources: Nelson et al. (2009) and CCSD (http://www.cambriawqcp.org/).

In addition, lagoon sandbar formation and breaching patterns are speculated to affect adult steelhead migration in Santa Rosa Creek (D. W. Alley & Associates 2008, Nelson et al. 2009). In drier winters there can be insufficient instream flow to breach and/or maintain an open sandbar during adult migration, possibly preventing adults from entering the lagoon from the ocean, or resulting in a later or shorter run of steelhead (D. W. Alley & Associates 2008, Nelson et al. 2009). In addition, winter sandbar breaching can be influenced by ocean conditions. (Sandbar monitoring data for the Santa Rosa Creek lagoon were not available for this effort.)

In summary, structural and flow-related barriers to steelhead are likely a limiting factor for steelhead in dry years, when they may prevent steelhead from entering the lagoon and can restrict steelhead to the lower 3–7 mi (4–11 km) of the creek, where spawning and rearing habitat is of poorer quality (see discussions below).

3.1.2 Spawning habitat quantity

CDFG surveys from the 1930s described extensive steelhead spawning habitat in Santa Rosa Creek watershed (Titus et al. 2006). In 1960, CDFG noted that spawning areas were abundant and in good condition throughout the lower 7 mi (11 km) of the stream, and scattered in the next 4 mi (Titus et al. 2006). Recent surveys have also documented a substantial amount of steelhead spawning habitat throughout the watershed from stream mile 0.2–13 (Nelson et al. 2009, D. W. Alley & Associates 2008). Nelson et al. (2009) identified a total of 175 pool tail crests and 183 other potential spawning sites appropriate for steelhead spawning in the mainstem, and noted that suitable spawning habitat also likely exists in the lower, accessible reaches of Mora and Lehman Creeks and the East Fork of Santa Rosa Creek (see Figure 1-2). At this time it does not appear that spawning gravel quantity limits production of steelhead in the watershed.

3.1.3 Spawning habitat quality

On Santa Rosa Creek, spawning habitat quality is primarily controlled by the degree of spawning gravel embeddedness, since it appears that in most years flows are sufficient to prevent dewatering of redds during the incubation period and deliver adequate levels of dissolved oxygen to developing embryos (D. W. Alley & Associates 2008, Nelson et al. 2009). High levels of embeddedness, a measure of the degree to which cobbles and gravels are buried by fine sediments (i.e., silt and sand), reduces the ability of females to move cobble to construct redds, and the survival of developing eggs. The *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 2004) indicates that embeddedness of 25% or less is considered good spawning substrate for steelhead; however spawning habitat with embeddedness less than 50% is generally considered suitable (Nelson et al. 2009, NCRWQCB 2006). Excess fine sediments can also decrease egg-to-fry survival by filling interstitial spaces of the redd gravels and reducing oxygen delivery to developing embryos (Chapman 1988). Various studies indicate that as the percentage of fine sediments in spawning gravels exceeds 20–30%, dramatic reduction in embryo survival occurs (Chapman 1988, Reiser and White 1988, NCRWQCB 2006). Embeddedness values in Santa Rosa Creek range from 33–51% in runs (D. W. Alley & Associates 2008) to generally less than 25–50% in pool tail crests (Nelson et al. 2009)[11]. Spawning gravel embeddedness ratings higher than 50% are generally restricted to the lower reaches (Nelson et al. 2009).

Whereas spawning habitat appears to be suitable and not limiting production in the upper reach of Santa Rosa Creek, CDFG has identified a lack of suitable spawning substrates from excessive fine sediment deposition as one of the primary constraints to successful spawning in the lower reaches (Nelson 1994, Nelson et al. 2009). The lower reaches of a watershed are natural places for fine sediments to accumulate due to their lower gradients, and the Perry/Green Valley Creek sub-watershed, which joins Santa Rosa Creek at approximately stream mile 3, delivers a large supply of fine sediment directly to lower reaches of Santa Rosa Creek (see Section 2.5). Until 2011, the Ferrasci Road crossing may have, under a range of flow conditions, restricted spawning to the lower 3.5 mi (5.6 km) of the creek, while inadequate flows through the middle reaches may restrict spawning to the lower 7 mi (11 km) of the creek for a considerable portion of the spawning season during dry winters (Nelson et al. 2009). Under these circumstances, particularly if repeated over a number years, poor spawning habitat quality in the lower reaches likely limits the success of steelhead spawning and juvenile production. This is supported by the lower densities of fall YOY steelhead in the lower reaches when compared to the upper reaches (2-19), although it should be stressed that summer rearing habitat limitations may also be influencing this pattern. Notably, analysis of data from D. W. Alley & Associates (2007) indicated that YOY densities in the lower (stream miles 0–8) and upper (stream miles 8–13) reaches were not significantly correlated from 1998–2006, suggesting that YOY steelhead production—and the factors limiting it (e.g., spawning gravel quality)—differed between the upper and lower reaches within a given year.

Very little is known about the quality or access to spawning habitat in the Perry/Green Valley Creek sub-watershed. Presence of juvenile *O. mykiss* in Perry and Green Valley creeks (CDFG 2003b and USFS 1999, as cited in Becker and Reining 2008) indicates that at least some successful spawning occurred there, in spite of their apparently degraded condition (Yates and Van Konyenburg 1998, Appendix A), although it is not known if these juveniles were the progeny of anadromous steelhead or resident rainbow trout.

[11] It should be noted that a high degree of variability can result from embeddedness measures that are collected with different methods, calculations, or observers (Rowe et al. 2003).

3.2 Summer Rearing Habitat

The relatively extended freshwater rearing of steelhead has important consequences for the species' population dynamics. The maximum number of steelhead that a stream can support is limited by food and space through territorial behavior, and this territoriality is necessary to produce steelhead smolts that are large enough to have a reasonable chance of ocean survival. Therefore, the number of YOY fish that a reach of stream can support is typically small relative to the average fecundity of an adult female steelhead.

The habitat requirements for different age classes of juvenile steelhead are relatively similar, except that as fish grow they require more space for foraging and cover. YOY steelhead can use shallower and slower habitat with finer substrates (e.g., gravels) to meet their energetic demands and escape predators than age 1+/2+ steelhead, which, because of their larger size, have higher energetic demands and require deeper, more complex pools, and coarser substrate or large woody debris for cover while feeding (Hartman 1965, Fontaine 1988, Spina 2003). Spina (2003) found that, in a short reach of Santa Rosa Creek near stream mile 11, most YOY steelhead used shallower water (<0.4 m) than age 1+/2+ steelhead (>0.4 m) and considerably greater availability of shallow habitat. Due to the greater frequency of shallow habitat and because YOY steelhead can generally utilize habitat suitable for age 1+/2+ steelhead, but age 1+/2+ steelhead can not use the shallower, finer substrate habitat suitable for YOY, a stream reach supports far fewer age 1+/2+ than YOY individuals during summer. Between 1998 and 2006 creek-wide densities of YOY steelhead in the fall were between 2.7 and 10.0 times higher than age 1+/2+ densities (D. W. Alley & Associates 2008) (Figure 3-3). For this reason, it is unlikely that YOY steelhead summer rearing habitat limits steelhead production. In support of this hypothesis, D. W. Alley & Associates (2008) reported that fall YOY densities in Santa Rosa Creek were the highest of nine streams surveyed on the Central California Coast in 2006. As such, the following sections generally focus on rearing conditions for age 1+/2+ steelhead.

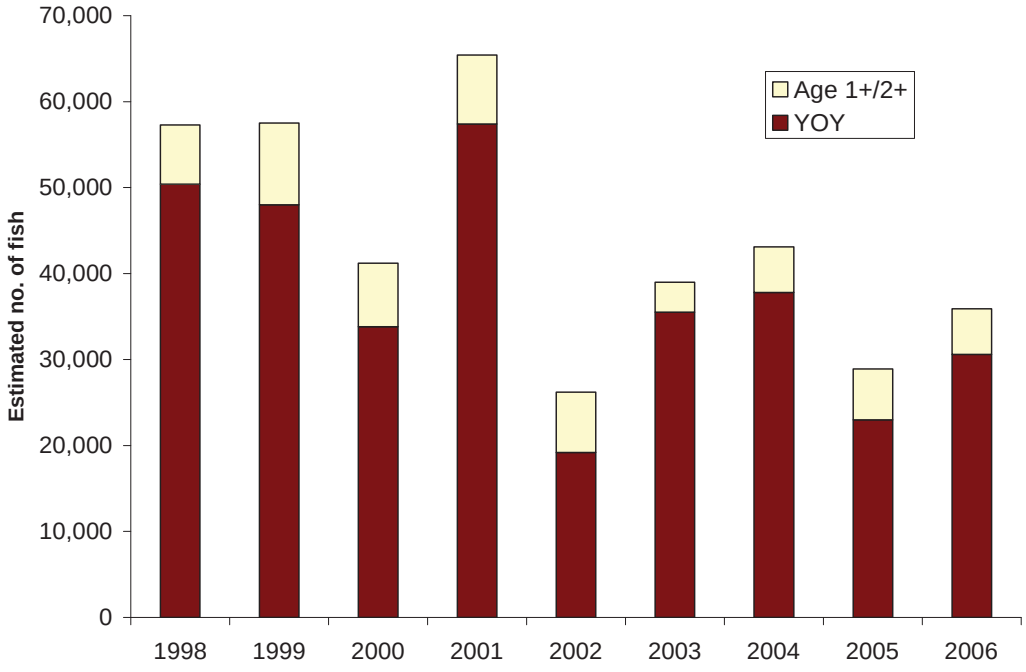

Figure 3-3. Creek-wide YOY and age 1+/2+ steelhead population estimates from 1998 to 2006. Data source: D. W. Alley & Associates (2007, Table 25a).

Juvenile steelhead carrying capacity is strongly influenced by instream flows during the summer, which influence overall rearing habitat area, the depth and volume of pool habitat, connectivity between habitat types, and water temperatures. Streamflow also dictates the quantity of drifting invertebrates that reach feeding steelhead, such that at higher summer flows steelhead can better maintain feeding rates that allow them to meet the metabolic demands of elevated summer water temperatures. Santa Rosa Creek likely experienced seasonally low flows, particularly during drought years, under natural conditions. However, due to groundwater pumping and water diversions, summer instream flows are chronically low compared to historic levels and are considered a critical factor limiting juvenile steelhead populations in Santa Rosa Creek (Yates and Van Konyenburg 1998, D. W. Alley & Associates 2008, Nelson et al. 2009). For example, in 2005, the wettest water year on record since 1998, discharge just downstream of Highway 1 was as low as 9 cfs by late May and was less than 2 cfs from late August until December (Nelson et al. 2009). During drier years, fall discharge measured by D. W. Alley & Associates (2008) was typically between 0.1 and 1 cfs at the downstream-most sampling site. While detailed analysis of how much flow is required to support steelhead summer rearing requirements (e.g., habitat connectivity, suitable stream temperatures, and invertebrate drift) in Santa Rosa Creek has not been conducted, it has been noted that instream flows are often inadequate to allow steelhead movement between habitat types in the late summer and fall (Rathbun et al. 1991, D. W. Alley & Associates 2007, Nelson et al. 2009). For example, flows in the mainstem Santa Rosa Creek go subsurface for approximately 0.5 mile (varying by year) near stream mile 7 during summer (D. W. Alley & Associates 2008, Nelson et al. 2009), eliminating rearing habitat and invertebrate drift in that reach and restricting it downstream.

In small coastal streams such as Santa Rosa Creek, pools are essential summer rearing habitat for age 1+/2+ juvenile steelhead (D. W. Alley & Associates 2008), although age 1+/2+ steelhead in Santa Rosa Creek have also been documented to utilize run habitat in the spring (Spina 2003). Pools must have sufficient depth, generally considered to be 2 ft (0.6 m), although this can depend on availability of escape cover and presence of predators and increases with fish size (Bjorrn and Reiser 1991, McEwan 2001, Spina 2003). In a 2,624-ft (800-m) reach of Santa Rosa Creek near stream mile 11, Spina (2003) documented age 1+/2+ individuals in water as shallow as 1 ft (0.4 m), but most individuals were in depths greater than 2 ft (0.6 m). Reductions in pool depth may adversely affect thermal and velocity refugia and reduce the potential to avoid predators. While recent surveys indicate pools comprise approximately one-third of habitat by stream length in the lower 13 mi (20 km) of Santa Rosa Creek, only about one-quarter were deep enough to be suitable rearing habitat for age 1+/2+ steelhead, and poor pool development has been cited as one of the primary limits on rearing habitat in Santa Rosa Creek (Rathbun et al. 1991; Nelson 1994; D. W. Alley & Associates 2007, 2008; Nelson et al. 2009). Substantially more pool habitat was located in the upper reaches above stream mile 8 than in the lower reaches from stream miles 0–8). Although pool filling as been attributed to fine sediment deposition (Nelson et al. 2009), the relatively high sediment-transporting capacity of the lower reaches of Santa Rosa Creek (see Section 2.5) suggests that poor pool development is likely due to the lack of large woody debris (see discussion below) and other elements that create and maintain pools (e.g., riparian tree roots), rather than solely infilling by fine sediment.

An important element of the pool habitat complexity required for juvenile steelhead rearing is escape cover. Also know as concealment cover or instream shelter, escape cover allows individuals to evade predators and, in the winter, to find refuge from high flows (Cunjak 1996, Spina 2003, D. W. Alley & Associates 2008). Escape cover in Santa Rosa Creek generally includes large, unembedded cobbles and boulders, undercut banks, large woody debris, and overhanging vegetation (D. W. Alley & Associates 2008, Nelson et al. 2009). Less than 20% of pools measured by Nelson et al. (2009) provided escape cover, and unembedded boulder/cobbles

and large woody debris were in short supply. Large woody debris is a key habitat component for juvenile steelhead, not only because it provides escape cover, but because it increases overall habitat complexity, facilitates temporary sediment storage, and forms scour points that create and maintain the deeper pools needed by larger juvenile steelhead (Harmon et al. 1986). Both Nelson et al. (2009) and D. W. Alley & Associates (2008) report a paucity of large woody debris in Santa Rosa Creek, with large woody debris making up only about 3% of the cover. A lack of large woody debris is not uncommon in California Mediterranean-climate streams, where historical land clearing and development near streams has decreased the supply of large wood, and woody debris that does make it into the stream are frequently removed due to real and perceived threats to flood control and near-stream infrastructure (Opperman 2002). The lack of large woody debris in Santa Rosa Creek is speculated to restrict carrying capacity of oversummering age 1+/2+ steelhead, since it limits escape cover and prevents the scour formation and maintenance of deep pools (Nelson 1994, Spina 2003, D. W. Alley & Associates 2008, Nelson et al. 2009).

Based on the relatively high abundance of YOY steelhead in the fall, summer rearing habitat is not likely limiting this age class, which is supported by the fact that they can use shallower riffle and pool habitat than age 1+/2+. Based on low abundance of age 1+/2+ compared with YOY, infrequent pools, and groundwater extraction, physical rearing habitat required by age 1+/2+ (and larger YOY) steelhead is very likely limiting summer carrying capacity, and possibly smolt production, in Santa Rosa Creek. However, as discussed in detail below, limitations in winter habitat for age 0+ and age 1+ could also explain this pattern. In addition, the degree to which rearing habitat limits the population may be influenced by habitat conditions in the lagoon. In some cases, lagoons provide rearing habitat capable of supporting large numbers of juveniles that are likely in excess of the summer or winter carrying capacities of stream reaches (Smith 1990, Hayes et al. 2008, Sogar et al. 2009), although this has not been evaluated in the Santa Rosa watershed in recent years. As described in Section 3.5 below, in the 1970s, the juvenile steelhead population in the lagoon was quite large (Bailey 1973 and Puckett 1970, as cited in Rathbun et al. 1991), indicating that it was a suitable and significant rearing habitat for the steelhead population.

3.3 Overwintering Habitat

Overwintering steelhead may suffer elevated mortality when they are displaced (or “entrained”) by high winter flows. Discharge in the inherently flashy Santa Rosa Creek can range from 1 cfs to over 12,000 cfs (as in 1969 and 2005), with winter flood events over 5,500 cfs typically occurring once every five years (Appendix A). Refuge from such flood events requires that steelhead access deeper interstitial spaces in the substrate or other cover to avoid turbulent, high velocity conditions. In general, many of the habitat elements essential for successful summer rearing are also essential for winter rearing.

Because steelhead tend to spawn and rear in higher gradient stream reaches with more confined channels, they have less propensity than other species (e.g., coho salmon) for using off-channel slackwater habitat in winter, and a greater propensity for using in-channel cover provided by cobble and boulder substrates. As such, interstitial spaces in cobble or boulder substrate are considered to be the key attribute defining winter habitat suitability for juvenile steelhead (Hartman 1965, Chapman and Bjornn 1969, Meyer and Griffith 1997). Cobble-boulder rearing habitat is most likely to occur in step-pool channels of confined, higher gradient reaches (Montgomery and Buffington 1997). As described in Section 2.5, cobble-boulder dominated habitat is more common in the upper watershed, much of which is upstream of potential fish passage barriers, and median grain size decreases downstream in almost direct proportionality to drainage area.

Steelhead will use cover in the form of large woody debris or off-channel habitat when it is available, especially in low-gradient reaches where interstitial spaces among cobble and boulder are less abundant. Many of the stream surveys in the Santa Rosa Creek watershed indicate some level of substrate embeddedness by fine sediment (Rathbun et al. 1991, Nelson 1994, D. W. Alley & Associates 2008, Nelson et al. 2009). When embeddedness of cobbles and boulders is greater than about 25% it greatly restricts their utility as escape cover (D. W. Alley& Associates 2008). Nelson et al. (2009) reported that only 26% of pools in Santa Rosa Creek had small cobble, large cobble, or boulders as dominant substrate, with the remainder being comprised primarily of silt, sand, or gravel. Pool tail crest surveys indicated that most large cobbles and boulders were highly embedded, with only one of the 47 locations surveyed having an embeddedness value below 25%. Much of the geology underlying the watershed has moderate to very high erodibility (Section 2.4), so there is naturally a greater potential for fine sediment in the creek channels, and winter habitat in the form of interstitial space may be naturally less abundant than in other coastal streams. Further, there are many anthropogenic sources of fine sediment in the watershed (Nelson et al. 2009, Appendix A). In particular, the Perry/Green Valley Creek sub-watershed delivers a large supply of fine sediment, with no corresponding coarse sediment component, directly to lower 3 m (5 km) of Santa Rosa Creek (see Section 2.5). In this case large woody debris may be more important as winter habitat than in a stream system with naturally available unembedded substrate. However, as described previously, recent stream surveys indicate a lack of large woody debris within the watershed (Nelson et al. 2009, D. W. Alley & Associates 2008).

As with summer habitat, a reach of stream will typically support far fewer age 1+/2+ than YOY steelhead in the winter because YOY are smaller and can utilize a wider range of substrate for refuge. For this reason, in the winter, habitat may often become unsuitable for age 1+/2+ steelhead at lower magnitudes of sedimentation than for YOY. Substrate will become less suitable for both summer and winter rearing at higher levels of embeddedness, but it will often be more limiting in winter because refuge from entrainment during winter freshets requires that steelhead hide deeper within the substrate. As a result, in many watersheds—even those containing poor summer habitat—it has been observed that winter rearing habitat limits steelhead populations in other central California coastal streams such as Lagunitas Creek (Stillwater Sciences 2008), San Gregorio Creek (Stillwater Sciences 2009), and Upper Penitencia Creek (Stillwater Sciences 2006b).

The relatively low abundance of age 1+/2 steelhead observed in fall suggests that either summer rearing habitat or winter rearing habitat is limiting smolt production in Santa Rosa Creek. However, in the absence of an assessment of the juvenile steelhead population in both the fall and the following spring, it is not possible to directly determine whether winter habitat is limiting. Based on the observed relatively low quantity of unembedded cobble-boulder habitat and a paucity of large woody debris (Nelson et al. 2009, D. W. Alley & Associates 2008, Appendix A) it is possible that winter habitat is limiting. Overall, winter habitat is expected to be less important than summer habitat in dry years that lack high flow events and have reduced summer flows. In these years, individuals are less susceptible to entrainment in the winter, while pool habitat and feeding opportunities are expected to be more restricted in the summer.

Juvenile steelhead

3.4 Bioenergetics

Numerous studies have examined the relationships between water temperature, growth, and survival of juvenile steelhead. Results of these studies vary between study populations. Recent studies of more southern populations of steelhead indicate that they can continue to grow at higher water temperatures (Spina 2007, D. W. Alley & Associates 2008, Sogard et al. 2009, Bell et al., in review) and will tolerate short periods of temperatures, up to approximately 81–84°F (27°–29°C) (depending on acclimation temperature), that were previously considered lethal (Myrick 1998).

Available data for Santa Rosa Creek indicate that, in most years, summer water temperatures are suitable for successful steelhead rearing in the majority of stream reaches. Maximum temperatures in the summer and fall of 2004–2006 rarely exceeded 69°F (21°C), particularly in the upper reaches above stream mile 8 (D. W. Alley & Associates 2008, Nelson et al. 2009). Temperature suitability for steelhead rearing may occasionally be exceeded in the lower reaches (below stream mile 8) in drier years (in the summer and fall of 2004–2006, maximum daily water temperatures commonly exceeded 75°F (24°C), but rarely exceeded 77°F (25°C) [D. W. Alley & Associates 2008, Nelson et al. 2009]), but there is still considerable uncertainty of what optimal temperatures for steelhead are in this region (A. Spina, pers. comm., 2010).

Available data suggests that despite periods of unsuitable water temperature in lower Santa Rosa Creek, steelhead continue to grow, and at rates reported to be higher than in nearby San Simeon Creek (D. W. Alley & Associates 2008, Sogard et al. 2009). Fulton condition factors for YOY and age 1+/2+ individuals captured in the fall of 2005 by Nelson et al. (2009) varied considerably, but, within size classes, were actually higher in the warmer lower reaches than cooler, upper reaches. In addition, both Nelson et al. (2009) and D. W. Alley & Associates (2008) found that the size of YOY fish increased steadily in the downstream direction. Although it is not certain whether YOY growth was higher in downstream reaches, if individuals emerged and begin feeding earlier in the spring there, or if larger individuals actively migrated downstream, together these results do suggest that water temperatures were not excessive and/or sufficient food was available in the lower 8 mi (13 km) of the creek during steelhead rearing. Age data from scale analysis and corresponding length data from 2006 (which had a relatively wet spring) support the finding that juvenile steelhead in the lower 8 mi (13 km) of Santa Rosa Creek generally have relatively high growth rates in their first year, with many individuals reaching 5–6 in (130–160 mm) fork length by fall (D. W. Alley & Associates 2008). Above stream mile 8 however, length frequency data of juvenile steelhead captured in October and November 2005 do show a large number of relatively small (2–3 in [50–80 mm] fork length) YOY fish (Nelson et al. 2009). The relatively lower condition factors and generally smaller fish captured above stream mile 8 suggests that food availability may be limiting growth in these reaches compared to the lower 8 mi (13 km).

Overall it appears that water temperature generally does not hinder juvenile growth in Santa Rosa Creek, likely because of mostly suitable water temperatures, natural adaptations to higher temperature, and possibly because of high food availability. However, there appears to be an inconsistency between the observed growth rates and the relatively small smolt sizes observed by the limited spring outmigrant trapping data in Santa Rosa Creek. Based on the size range of YOY observed in the lower reach (5–6 in [130–160 mm] fork length) in fall, most smolts would be expected to be greater than 7 in (170 mm) by spring. Instead, the majority of smolts captured during spring outmigrant trapping in 2005 averaged 6.5 in (165 mm) fork length (Nelson et al. 2009). Several studies have shown a strong relationship between the size at which a steelhead smolt migrates to the ocean and the probability that it will return to spawn (Kabel and German

1967, Hume and Parkinson 1988, Ward et al. 1989, Bond et al. 2008). In one the most focused studies on marine survival in a central California coastal watershed, Bond et al. (2008) found that, in Scott Creek in Santa Cruz County, few returning adults were smaller than 6 in (150 mm) at ocean entry and the majority were larger than 8 in (200 mm). Similarly, Ward et al. (1989) found that only smolts greater than 7 in (170 mm) typically experienced relatively high marine survival (>10%). Assuming that size-dependent survival and ocean conditions experienced by the Santa Rosa Creek populations are similar to these other populations, it is possible that in some years (e.g., 2005) most smolts from Santa Rosa Creek have poor ocean survival due to their small size. As a comparison to other southern California watersheds, in the Santa Clara River smolts in 2009 averaged 7 in (185 mm) fork length (S. Howard, pers. comm., 2010); in the Santa Clara and Santa Ynez estuaries most smolts in 2007/2008 were greater than 7 in (170 mm) fork length (Kelley 2008), and in Topanga Creek nearly all smolts captured during spring 2009 were greater than 7 in (170 mm) (Bell et al. in review). Based on the 2005 outmigrant trapping results, there is the potential that relatively small smolt sizes in Santa Rosa Creek (and therefore poor ocean survival) are a potential limiting factor for the population. However, since outmigrant trapping occurred at stream mile 0.3, and there were growth opportunities in the riverine and lagoon habitat downstream of the trap, it is not clear if captured individuals continued to rear and grow in the lagoon before leaving for the ocean, as observed in other systems (Smith 1990, Hayes et al. 2008). The extremely high growth of some YOY—as indicated by annual growth rings on their scales—collected just upstream of the lagoon (D. W. Alley & Associates 2008), suggests that food resources are likely high in lower Santa Rosa Creek. Clearly, additional outmigrant trapping data, and determining growth opportunities and residency within the lower creek and lagoon, is critical to assessing if smolt outmigrant size is a limiting factor in Santa Rosa Creek.

3.5 Lagoon Habitat

Coastal lagoons are fed mostly by freshwater streamflow and are generally separated from the sea by a sandbar, except when that sandbar is breached during high-flow events or when sea water overwashes the sandbar. Lagoon rearing has been demonstrated to be critically important for other central California coast steelhead populations, with significantly higher growth rates and ocean survival by steelhead that reared in lagoons, even with lagoon water temperatures as high as 75°F (24°C) (Smith 1990, Hayes et al. 2008, Bond et al. 2008). While no studies of lagoon rearing, growth, and survival have been carried out in Santa Rosa Creek, these findings from other central California coast watersheds highlight the potential importance of the Santa Rosa Creek lagoon for steelhead rearing. Since larger smolts tend to have higher ocean survival, growth during lagoon rearing may increase ocean survival of steelhead smolts. It appears that if lagoons are well-mixed (i.e., not salinity stratified), or comprised of mostly freshwater, they can maintain a relatively cool, well-oxygenated, and food-rich environment that provides high quality habitat for juvenile steelhead (Smith 1990). This can potentially relax to some degree the density-dependent bottleneck occurring in stream habitat and provide a high growth environment and adjustment to a saline environment that improves ocean survival for both stream and lagoon reared fish. Conversely, when lagoons are highly saline, or salinity-stratified, they collect heat in the lower saltwater layer, have relatively lower dissolved oxygen levels, and typically have unsuitable conditions for rearing.

Full lagoon in winter

While very little historical or current data exist on the juvenile steelhead population in Santa Rosa Creek lagoon, what data are available suggests it has declined. In the 1970s, the juvenile steelhead population in the lagoon was estimated to be between 2,290 and 6,800 (Bailey 1973 and Puckett 1970, as cited in Rathbun et al. 1991), suggesting that it was a suitable and potentially important rearing habitat. By the 1980's it appears that little if any steelhead rearing occurred in the lagoon (Holland, unpubl. data, as cited in Rathbun et al. 1991). While ineffective at detecting juvenile steelhead, sampling for tidewater goby in the lagoon from 1993–2007 provides evidence that, in some years, both YOY and smolt-sized steelhead utilize the lagoon for rearing in the summer and fall. In summer and fall sampling in 2004, Alley and Sherman (2006) captured 101 and 69 juvenile steelhead, respectively between Shamel Park and the Windsor Bridge. No steelhead were captured in 2005, but visual observations of steelhead in the lagoon were made (Alley and Sherman 2006). Outmigrant trapping conducted in spring 2005 at stream mile 0.3 also suggests that a portion of the juvenile steelhead population likely migrates into the lagoon prior to smolting: numerous individuals measuring between 2 and 5 inches (50 and 140 mm) and having parr coloration were captured (Nelson et al. 2009). It is not clear whether these individuals were displaced due to limited carrying capacity in upstream reaches, or if they were preferentially exhibiting a lagoon rearing life history strategy.

It is unclear to what extent Santa Rosa Creek lagoon provides suitable conditions for juvenile rearing. While the lagoon may provide quality over-summering habitat in some years, it likely becomes too saline and warm for juvenile steelhead survival in others (D. W. Alley & Associates 2008). The quality of lagoon rearing habitat for steelhead is largely dependant on sandbar formation and maintenance, the amount of freshwater inflow, and water quality conditions. When sandbar breaching is delayed or cut short, either from inadequate instream flows or ocean conditions, adult steelhead are unable to enter the creek and spawn (they typically stray into other nearby creeks). The presence of smolt-sized individuals in Santa Rosa Creek lagoon after sandbar closure, suggests that outmigrating individuals may be "trapped" in the lagoon when the sandbar reforms early in the season (D. W. Alley & Associates 2006). Survival of smolts that rear in the lagoon is not known. Conversely, if the sandbar is breached artificially in the summer (natural breaching during the summer is rare), lagoon habitat can be rapidly reduced and become too saline for rearing steelhead. Fortunately, artificial breaching of the Santa Rosa Creek lagoon is not known to occur (M. Walgren, pers. comm., 2010).

Reduced instream flows limit the extent of lagoon habitat and affect the dynamics of lagoon formation, causing extended periods of saltwater and freshwater stratification that lead to thermal stratification, with warmer temperatures and anoxic conditions along the bottom that lower dissolved oxygen levels and reduce food supplies (Smith 1990, Capelli 1997). In some lower flow years such as 2003 and 2004, entire sections of the Santa Rosa Creek lagoon dried up, reducing the area of suitable steelhead rearing habitat (D. W. Alley & Associates 2008).

Water temperatures and DO levels in the lagoon, particularly at the bottom, can frequently exceed lethal limits for steelhead in the summer and fall (see Section 2.8.1). Although low DO may restrict the scope of steelhead activity in lagoon, D. W. Alley & Associates (2008) hypothesizes that low DO levels are less limiting than temperature to steelhead survival in the lagoon. The observed high water temperatures and low DO levels likely create seasonally unfavorable conditions for rearing steelhead and may limit smolt growth, survival, and production in the watershed in some years. Nonetheless, it is possible that the productive, food-rich lagoon allows juvenile steelhead to successfully rear in the lagoon, even when water temperatures reach moderately high levels for short periods. Overall, the lagoon habitat is predicted to be a crucial component of the life history of steelhead in Santa Rosa Creek and has the potential to increase

the carrying capacity of the watershed, alleviating some of the limitations from poor habitat conditions in stream reaches and contributing to recovery of the population.

Although much of the above discussion describes stream and lagoon habitat separately, they are better viewed as connected habitat features. Just as upstream conditions such as freshwater inflow and sediment delivery affect lagoon characteristics, demographic processes such as immigration and emigration link steelhead population dynamics within stream and lagoon habitat. Thus, steelhead populations are typically limited by a combination of density-dependent processes occurring within stream reaches, and the degree to which seasonal rearing opportunities and water quality in lagoon habitat augment carrying capacity in the watershed. For example, if it is initially assumed that winter or summer habitat conditions limit the carrying capacity of stream reaches, it would then be assumed that the ability of lagoon habitat to support steelhead in excess of stream carrying capacity is dependent on the degree to which freshwater inflow interacts with, or displaces, saline water to prevent salinity stratification, which is affected by annual variability in timing of sandbar formation and amount of freshwater inflow.

Increasing winter carrying capacity for YOY steelhead may increase the abundance of juvenile fish until summer habitat for age 1+/2+ steelhead becomes limiting. After winters with high YOY survival, an age 1+/2+ summer habitat bottleneck may develop if pool habitat becomes limiting. However, behavioral emigration of “excess” age 1+/2+ steelhead surviving the winter could increase production if suitable habitat is available in the Santa Rosa Creek lagoon. Besides the ocean life stages, utilization of lagoon habitat is perhaps the least understood component of steelhead population dynamics and ecology in the watershed. For this reason, it is important to implement targeted studies describing the lagoon water quality and habitat conditions as they relate to juvenile steelhead use, growth, and survival.

3.6 Summary of Limiting Factors and Uncertainties

Based on historical evidence, the Santa Rosa Creek watershed supported a robust population of steelhead. There are many ecological characteristics of the watershed that continue to be relatively healthy compared to other streams in the region, and steelhead continue to persist in Santa Rosa Creek despite drastic declines in neighboring watersheds. These characteristics, including high quality habitat in the upper reaches (stream miles 8–13), moderate water temperatures, and an intact lagoon system, highlight the regional significance and potential of this watershed to protect and recover nearby steelhead populations.

A wide range of factors, however, affect the freshwater life stages of steelhead in Santa Rosa Creek. Rather than listing all elements that potentially influence the population (see D. W. Alley & Associates [2008] for a detailed discussion), the limiting factors analysis was used to generate the following hypotheses of the highest priority and most likely causes of the decline in steelhead abundance in the watershed. In turn, these hypotheses are the basis of several of the management and restoration recommendations in Section 4. Overall, the analysis results in the following hypotheses of high priority limiting factors in the watershed:

1. Restricted access to spawning habitat limits steelhead spawning and juvenile production. In dry water years the dry middle reaches can confine spawning adults to the lower reaches.
2. When confined to the lower reaches, steelhead spawning success is limited by poor quality spawning habitat. Potential spawning substrates in the lower reaches are embedded by fine sediment.

3. Low instream flows during the summer reduce summer rearing habitat for age 1+/2+ steelhead and limit the population, particularly during drier water years.
4. Inadequate large woody debris and to a lesser extent fine sediment filling of pools (primarily below Perry Creek), restrict formation and maintenance of complex summer rearing pool habitat for age 1+/2+ steelhead and limit the population.
5. Inadequate large woody debris, embeddedness of cobbles and boulders, and fine sediment filling of pools, limits the overwinter survival of YOY and age 1+/2+ steelhead, particularly during years with flood events.

In conducting the limiting factors analysis of steelhead in the Santa Rosa Creek several uncertainties and data gaps were identified. Filling these data gaps is fundamental to refining, and potentially eliminating, some of the limiting factor hypotheses posited above. These data gaps are the basis of several of the research recommendations in Section 4.

1. Given the uncertainty in recent escapement levels, adult trapping and/or detection in Santa Rosa Creek is needed to monitor annual population success and collect baseline data for the evaluation of population response to implemented restoration actions. Due to the difficulty in monitoring steelhead spawning in creeks with small steelhead populations and dispersed spawning habitat, CDFG recommends the use of traps, weirs, and/or video or sonar detection systems to provide an absolute count of migrating adults (Adams et al. 2011).
2. Juvenile population sampling (e.g., snorkel surveys) is needed in conjunction with fall sampling to differentiate overwinter from oversummer survival. This would need to be done over several years to help elucidate the dependence of winter and summer survival on variation in rainfall and stream flow.
3. A better understanding of residency timing, duration, and growth in the lagoon is needed to determine the suitability of the lagoon for rearing and the influence lagoon rearing has on smolt growth and ocean survival.

4 RECOMMENDATIONS

There are many ecological characteristics of the Santa Rosa Creek watershed that have not been as adversely impacted in terms of steelhead habitat requirements compared to other streams in the region—for example moderate stream temperatures and an intact lagoon system. However, based on the Watershed Synthesis, Steelhead Limiting Factors Analysis, Geomorphic Assessment (Appendix A), and benthic macroinvertebrate sampling (Appendix B), some watershed conditions have been degraded and will require restoration or enhancement to achieve significant protection and recovery of the steelhead population.

The primary objective of the recommendations provided in this section is to address the factors currently believed to be limiting the steelhead population. Additional objectives of these recommendations are to provide for the long-term protection of key ecosystem components that are intact, restore, or enhance ecosystem components that require it, and fill key gaps in the understanding of the watershed and steelhead population. Because there are a number of ways in which these objectives can be met, the recommendations have been organized based on their specific goal, resulting in eight categories. These goals are listed in order of their relative importance to steelhead habitat restoration:

- Increase Summer and Fall Instream Flows
- Restore the Riparian Corridor
- Reduce Fine Sediment Delivery to the Creek
- Conserve and Protect Open Spaces and Existing Land Uses
- Increase Woody Debris Supply and Retention
- Remove Barriers to Fish Passage
- Fill Key Data Gaps
- Reduce Mercury Supply

The recommendations serve as a guide to improving habitat conditions in the Santa Rosa Creek watershed for steelhead, based on identified limiting factors. If implemented, these actions will also benefit other aquatic and terrestrial species. In addition, they are compatible with current land uses in the watershed: reducing land erosion, maximizing efficient rural and urban water use, and conserving agricultural land use that has been part of this watershed for two centuries are compatible with many concerns voiced by stakeholders throughout the watershed planning process.

The recommendations have been developed to be implemented individually, although appropriate combinations and phasing are described, and on a voluntary basis, by or with the consent of willing landowners. They are not intended as prescriptions or requirements. Together, the full suite of recommendations presents multiple ways to address steelhead limiting factors and provides an integrated watershed management plan that will serve various local organizations and individuals for both the near- and long-term. As these are all voluntary actions, various funding sources are available to fund some or all of the recommendations described below (see Appendix D). One advantage of this plan is to serve as a document to support funding for restoration activities in the watershed.

4.1 Increase Summer and Fall Instream Flows

Insufficient instream flow during the summer and fall, as a result of groundwater extraction and riparian diversions, has been identified as the primary factor limiting summer rearing habitat and juvenile steelhead survival in the watershed (Rathbun et al. 1991, Nelson 1994, Yates and Van Konyenburg 1998, D. W. Alley & Associates 2008, Nelson et al. 2009). The recommendations below for increasing summer and fall instream flows include immediate actions, such as water conservation and constructing off-stream storage, as well as updating the water budget and identifying steelhead instream flow requirements, which are necessary to identify specific measures and locations that would be most effective in increasing summer and fall instream flows. These recommendations can be implemented to begin the process of reducing demand for surface and groundwater supplies in the summer and fall, and could also improve the quality and quantity of rearing habitat in the lagoon by increasing the amount and duration of freshwater inflow.

4.1.1 Implement water conservation and reuse strategies

To reduce the amount of water diverted from the stream and pumped from the groundwater basin, and potentially maintain summer and fall instream flows, it is recommended that municipal, domestic, agricultural, and recreational water conservation strategies, including water reuse, be implemented. It is further recommended that additional water conservation opportunities, such as using non-potable water for outdoor landscaping and irrigation, be pursued by CCSD. Per the San Luis Obispo County (2008) North Coast Area Plan, any new development resulting in increased water use should offset such an increase by retrofitting water fixtures, replacing irrigated landscaping with xeriscaping, or other verifiable actions to reduce water use. It is also recommended that water reuse, such as the direct reuse of sufficiently treated wastewater or groundwater replenishment with treated wastewater, be further evaluated in the Santa Rosa Creek watershed. A 2004 Recycled Water Master Plan prepared by CCSD estimated that approximately 50 acre-feet of water could potentially be provided through the use of recycled water, with no net increase in groundwater pumping (R. Gresens, pers. comm., 2012). Currently, Santa Rosa Creek watershed-derived municipal wastewater is treated and allowed to filter into the San Simeon Creek groundwater basin. Given the scarcity of water resources in the region, developing ways to retain and use this water in the watershed would be beneficial.

Local Resource Conservation District, Natural Resources Conservation Service, and Farm Bureau resources are available to assist rural residents and farmers in the watershed in implementing water conservation and reuse strategies. Examples of broad categories of voluntary on-farm and rural water conservation and reuse strategies include:

- Irrigation Management and Scheduling: The local Resource Conservation District's Mobile Irrigation Lab can provide on-site distribution uniformity evaluations of individual irrigation systems. Deciding when and how much water to apply to a field has a significant impact on the total amount of water used by the crop, water use efficiency, and irrigation efficiency. A number of different scheduling systems have been developed that can use either soil/plant- or atmosphere-based measurements to determine when to irrigate. Using a more scientific approach to irrigation scheduling has generally been shown to decrease the amount of water applied while improving yield.
- Tail Water Return Systems: To provide adequate water to the low end of the field, surface irrigation requires that a certain amount of water be spilled or drained off as tail water. Tail water return systems catch this runoff and pump the water back to the top of the field for reuse.

- Reduced Tillage and Cover Crops: The use of cover crops between crop rows or crop seasons and reducing soil tillage increases soil water storage capacity by capturing runoff and minimizing evaporation.
- Plant Species Options: Use drought tolerant forage and horticultural/landscaping plant species can help reduce water use.
- Keyline Design: Keyline design captures water at the highest possible elevation and spreads it outward toward drier ridges using plow lines and gravity, thereby reversing the natural concentration of water in valleys. Maximizing the distribution of water to drier ridges using precise plow lines that are slightly off-contour slows the movement of water and spreads it more uniformly, infiltrating it across the broadest possible area.

4.1.2 Construct off-stream closed water storage

Off-stream water storage of extracted groundwater and riparian diversions for domestic and agricultural uses, which would divert water during higher instream flow conditions in the winter and store it for use in the summer and fall, is one way of achieving additional instream flows for steelhead rearing and fall migration during dry water years. Water for off-stream storage would be diverted in winter only, with an elimination of spring, summer, and/or fall water rights. Off-stream closed water storage facilities (e.g., above-ground water tanks, cisterns, etc.) are maintained along several tributaries in the watershed; it is recommended that opportunities to increase their efficiency as well as to increase the number of facilities in strategic locations be pursued.

Storage tank in Santa Rosa Creek watershed

There have been several recent and successful efforts to increase summer and fall instream flows through water rights transfers and off-stream storage construction that may serve as a model for efforts in the Santa Rosa Creek watershed. In particular, the Mattole Headwaters Groundwater Management Plan 1.0 (Sanctuary Forest 2008) provides an example that, although from a northern California salmonid stream, is likely highly relevant to the Santa Rosa Creek watershed.

4.1.3 Purchase water rights from willing sellers for instream flows

California amended its Water Code in 1991 to allow for the purchase and transfer of water rights to instream flows. While water rights issues are technically and legally complex, and the effect of a single water rights claim on instream flows is typically not known, this could be a strategy for increasing summer and fall instream flows in Santa Rosa Creek. Water rights purchases would be based on willing sellers/donors. Purchased rights could be transferred to instream flows, with an entity such as CDFG or a land trust holding the right, or from a summer to winter diversion if off-stream storage is available (see recommendation above). Individual purchases and transfers will likely require significant research to understand the characteristics of the water right, assess second and third party impacts, and ensure the transfer is legitimate. If, based on this research, a purchase from a willing seller/donor is feasible and appropriate, an application for transfer would need to be prepared and finalized in accordance with SWRCB or governing agency specifications.

4.1.4 Conduct stream gauging and develop an updated water budget

Although Yates and Van Konyenburg (1998) provide insight into the effect of CCSD's municipal groundwater pumping and private groundwater pumping and water diversions on flow conditions in Santa Rosa Creek through the early 1990s, a more detailed and updated water budget is necessary to understand the effect of domestic and agricultural water extraction on instream flow levels, particularly during low-flow seasons. This level of understanding is important to identifying site-specific measures to increase instream flow levels and developing reasonable goals for minimum instream flow maintenance under a range of water-year types. Due to the technical and political complexities of developing an updated water budget, one option is that a sample set of private wells and surface water diversions be monitored and that the data be kept confidential. It is recommended that monitoring data be analyzed on an approximately annual basis to determine both the total amount of water pumped from the watershed and/or specific sub-watersheds during different water-year types and, in conjunction with instream flow measurements, the influence of groundwater pumping and surface water diversions on seasonal instream flow levels. An updated water budget would also contribute to the County's North Coast Area Plan requirement that any new development in Cambria not using a CCSD connection must assure no adverse impacts to Santa Rosa Creek (San Luis Obispo County 2008).

Currently there is no single consistent or accurate source of stream flow data in the watershed, which are necessary to provide useful and reliable data for an updated water budget. This is essential to understanding changes in watershed conditions, developing meaningful measures to increase instream flows, and monitoring the effectiveness of implemented actions. This could be done most efficiently by bringing the stream gauge at the Main Street Bridge up to current USGS-protocols for stream gauge operation and calibration. The primary requirement at present is for a campaign of flow measurements aimed at robustly calibrating the gauge during low and high flows. In addition to improving the gauge at Main Street Bridge, it is recommended that additional stream flow gauges be installed upstream of the lagoon to record flows that include all tributaries and in the vicinity of Mammoth Rock to record flows in the portion of the watershed with relatively consistent perennial flow.

4.1.5 Reduce future municipal groundwater pumping

Per the San Luis Obispo County (2008) North Coast Area Plan, if/when the proposed desalination plant is operational, it is recommended that CCSD water withdrawals from the Santa Rosa Creek aquifer be limited to help protect instream flows in the lower reaches of Santa Rosa Creek (i.e., those reaches affected by CCSD pumping), as well as the aquifer itself and agricultural resources. If planned and operated strategically, the proposed desalination plant could reduce the need for municipal groundwater pumping along Santa Rosa Creek and help to conserve instream flow in the summer and fall.

4.2 Restore the Riparian Corridor

Native riparian vegetation is fundamental to maintaining summer and winter rearing habitat elements that are likely limiting the steelhead population in Santa Rosa Creek. A functioning riparian corridor with overhanging vegetation moderates stream temperatures by shading the channel, provides a source of large woody debris and roots that interact with streamflows to force the development of pools for rearing habitat, and provides leaf litter for aquatic invertebrate, as well as terrestrial invertebrate, prey species. By providing these ecosystem benefits, riparian restoration will also improve steelhead rearing conditions in the lagoon by moderating water temperatures and contributing to the food supply. Riparian vegetation also reduces streambank

erosion, filters fine sediment and nutrients from runoff, provides wildlife movement corridors, and prevents non-native invasive plant species from becoming established. The following recommendations to restore the riparian corridor, several of which overlap with previous recommendations by CDFG (Nelson 1994, Nelson et al. 2009), will enhance summer and winter steelhead rearing habitat elements, reduce streambank erosion and fine sediment supply, and help conserve more natural streambank conditions in the lower reaches.

4.2.1 Revegetate degraded streambanks

To facilitate and expedite the restoration of a dense, multi-storied riparian corridor that provides multiple ecosystem services and benefits, it is recommended that native riparian trees and shrubs be planted in suitable areas. Examples of suitable areas include reaches where cattle have been excluded or are otherwise unable to graze on revegetated plants, and in areas where natural recruitment of riparian vegetation is not expected to occur in the near-term, such as steeper streambanks, higher elevation benches, or in strategic locations in or around bank revetment. Active revegetation may also be suitable soon after non-native invasive plant removal efforts (see below) to quickly restore vegetative cover and minimize the potential for re-infestation.

Intact riparian vegetation in lower Santa Rosa Creek

While planting palettes need to be selected based on site-specific conditions (e.g., elevation above baseflow, soil type, and groundwater level), alder (*Alnus rubra*), willow (*Salix* spp.), cottonwood (*Populus* spp.), sycamore (*Platanus racemosa*), big-leaf maple (*Acer macrophyllum*), and mulefat (*Baccharis salicifolius*) are examples of native trees and shrubs that may be appropriate for revegetation on streambanks and in wetter areas. In some cases, such as in the middle reaches, steep streambanks may need to be graded before planting. In upland or drier areas, coast live oak (*Quercus agrifolia*), blue oak (*Q. douglasii*), madrone (*Arbutus menziesii*), manzanita (*Arctostaphylos* spp.), California sagebrush *(Artemisia californica*), sage *(Salvia* spp.*),* toyon (*Heteromeles arbutifolia*), and coyote bush (*Baccharis pilularis*) may be appropriate. To the greatest extent possible, planting stock should be collected from the Santa Rosa Creek watershed to maintain genetic integrity. Planting at the onset of the rainy season can greatly reduce and even eliminate the need for irrigation, particularly in areas where plant roots can be expected to reach groundwater quickly. The use of cuttings, particularly for willow, cottonwood, and mulefat, can be another way to reduce the cost of revegetation efforts.

4.2.2 Manage grazing to reduce impacts to the riparian corridor

Cattle currently graze on streambanks and access the stream channel in several reaches of Santa Rosa Creek, as well as throughout the lower Perry/Green Valley Creek sub-watershed (Nelson et al. 2009, Appendix A). Such grazing can have severe impacts on riparian and instream conditions, including denuded streambanks, increased water temperatures, increased streambank erosion, and water quality contamination (Armour et al. 1994, Belsky et al. 1999), to the extent that fish populations are impacted (Platts et al. 1985, Ohmart 1996). It is recommended that grazing in the Santa Rosa Creek watershed be managed to reduce impacts to the riparian corridor. This could include the installation of fencing to exclude cattle from streambanks and the channel, as previously recommended by CDFG (Nelson et al. 2009), or other practices to limit access and

use of the riparian corridor by cattle, such as off-channel watering. Ideally these voluntary efforts would be focused on the denuded reaches of upper Santa Rosa Creek, the intermittent portion of the middle reach of Santa Rosa Creek, and in the Perry/Green Valley Creek sub-watershed. In the intermittent middle reach, where surface flow loss to groundwater may already limit the extent of riparian vegetation, cattle grazing is likely exacerbating streambank erosion and further preventing riparian vegetation to persist. In the Perry/Green Valley Creek sub-watershed, cattle grazing has denuded streambanks and is contributing to streambank erosion that supplies fine sediment to the lower reaches of Santa Rosa Creek.

4.2.3 Minimize the need for bank protection

While bank protection such as concrete, rip-rap, and gabion baskets can be necessary to protect infrastructure near the creek, particularly in emergency situations, it degrades riparian and instream habitat by precluding native vegetation and simplifying the channel, and, as observed on Santa Rosa Creek in the town of Cambria, often shifts the erosion upstream or downstream of the rip-rap or to the opposite bank (Nelson et al. 2009). Conserving and restoring streambanks and floodplains through the recommendations above will help minimize the need for bank protection by preventing development near the creek (that might subsequently require protection) and decreasing the erodibility of the banks. Where roads or buildings are threatened by streambank erosion, it is recommended that the potential to “train” the creek away from these areas be investigated as an alternative to hardened bank protection. For example, the bar opposite the eroding streambank could be manipulated (e.g., skimmed or cut) to direct flow closer to the middle of the channel and away from the eroding bank. The feasibility of such an approach is dependent upon site-specific conditions (e.g., access for heavy equipment, and the condition of upstream and downstream areas) and must be evaluated accordingly. However, it presents several significant benefits compared with hardened bank protection: it addresses the cause rather than just the symptom of bank erosion; and it conserves existing, and may even help improve, riparian and instream habitat conditions.

As previously recommended by CDFG, where bank protection is necessary, it is recommended that bio-engineering alternatives to rip-rap and other hard measures be implemented. Many of these alternatives are described in CDFG’s California Salmonid Stream Habitat Restoration Manual (Flosi et al. 2004). Streambank soil bioengineering, for example, typically includes installing large woody debris and/or boulder structures and planting interstitial (i.e., exposed) bank surfaces with quick growing vegetation, such as willows. The exposed large woody debris, boulders, and planted vegetation dissipates flow velocities against the bank toe and bank surface, and planted vegetation physically holds bank substrates (silts and sands) in place, thus increasing bank strength. Exposed large woody debris and planted vegetation will, in turn, also contribute to over-summer and over-winter habitat improvements for steelhead by scouring pools and providing cover. Separate or in combination with soil bioengineering, a bio-fabric can be applied across the bank surface to shield the bank high flow velocities and holds bank soils in place, and/or steep streambanks can be re-contoured (i.e., re-shaping) to create a more gently-sloping profile and increase resistance at the bank toe. A more gently-sloping bank has a lighter load above the bank failure plane and is, therefore, better able to withstand toe scour and/or undercutting than a vertical bank.

4.2.4 Treat non-native invasive species

As described in the Watershed Synthesis, a number of non-native invasive plant species that have the potential to degrade riparian habitat by replacing native species and altering physical conditions have been documented in the Santa Rosa Creek riparian corridor. Several of these

species, including several large-scale infestations of cape-ivy, isolated occurrences of arundo, pampas/jubata grass, eucalyptus, and French/Scotch broom are priorities for treatment efforts to promote the natural regeneration and growth of native vegetation and prevent further infestations. Removal of large areas of non-native vegetation is generally done in conjunction with riparian restoration so as to prevent the re-colonization of the area by non-native species.

However, the vast majority of the remaining watershed area has not been surveyed for non-native invasive species, where infestations can easily expand to downhill or downstream locations. For example, ponds in the Perry/Green Valley sub-watershed, which is largely un-surveyed, are likely a major source of bullfrogs to lower Santa Rosa Creek. Identifying small or recently established populations early on is important, since these are easier to control and/or eradicate. In addition, understanding broader patterns of non-native invasive plant distribution is important to increase the effectiveness of treatment measures and reduce the potential for later or downstream re-infestations. Therefore, it is recommended that the locations and populations of persistent non-native, invasive species in the riparian corridor be mapped and described. The inventory needs to conclude with a summary of identified species (in terms of their potential detriment to the ecosystem, rate of infestation, and methods of control) and priorities and designs for control measures.

Based on the non-native invasive species identified in the watershed, and the severity of their infestation, site-specific treatment methods need to be developed. Treatment methods should be selected that are appropriate for the site, minimize disturbance to adjacent natural areas, and do not result in unintended effects on non-target species. When appropriate, treatment methods should be implemented by trained and/or licensed crews. In some cases, non-native species can be discouraged and/or controlled by properly managed, targeted maintenance activities. For example, grazing practices can be managed to encourage and restore native species over non-native grasses and forbs.

4.3 Reduce Fine Sediment Delivery to the Creek

Summer and winter rearing habitat in the lower reaches (stream miles 0–3.5) of Santa Rosa Creek is partially degraded by excess fine sediment input. Fine sediment embeds larger substrates, limiting their use for spawning and as refuge from high flows, and can fill pool habitat that is used during both summer and winter rearing. The following recommendations focus on two of the most problematic sources of fine sediment identified in the Geomorphic Assessment (Appendix A): the Perry/Green Valley Creek sub-watershed and road-related streambank erosion. Fine sediment supply from excessive streambank erosion would be addressed through the riparian restoration recommendations made above. It is recommended that initial treatment of fine sediment sources, wherever they are conducted, be implemented as an adaptive management experiment, with monitoring to determine if treatments are effective at reducing substrate embeddedness and/or pool infilling.

In addition, it is recommended that fine sediment source treatments be conducted in coordination with other recommendations to improve winter rearing habitat in mainstem Santa Rosa Creek, further test the hypothesis that winter habitat is limiting steelhead production in the watershed, and assess the effectiveness of the actions. Based on the monitoring results of initial efforts, it can be determined whether to expand and/or revise treatment of fine sediment in the future. Remediating sources of fine sediment, particularly in the Perry/Green Valley Creek sub-watershed is also likely to increase the extent of rearing habitat in the lagoon by reducing the amount of aggradation.

4.3.1 Maintain roads to decrease hillslope and streambank erosion

San Luis Obispo County is responsible for the maintenance of Santa Rosa Creek Road and others in the watershed. Road-related runoff is the cause of much of the hillside and streambank erosion that is frequently observed in the watershed. Often, improperly placed ditches and culverts (or a lack thereof) concentrate winter runoff from roads where it can actively erode hillslopes or streambanks. Such erosion currently threatens Santa Rosa Creek Road at several locations. Road maintenance actions taken by the County would correct drainage features that currently concentrate runoff to unsuitable locations. It is recommended that culvert or ditch improvement or relocation be considered by the County at several locations (particularly where the road base is threatened) in the short-term, while out-sloping of roads (to discourage the concentration of runoff) may be more appropriate in the long-term.

Erosion at Santa Rosa Creek Road

4.3.2 Reduce and/or retain fine sediment delivery from the Perry/Green Valley Creek sub-watershed

Sediment delivered from the Perry/Green Valley Creek sub-watershed consists almost entirely of fine sediment (Appendix A). This supply is almost certainly a significant contributor to the lower quality spawning and rearing habitat conditions in the lower reaches of Santa Rosa Creek. Based on the Geomorphic Assessment (Appendix A) a number of measures are potentially appropriate to reduce fine sediment to and from the Perry/Green Valley Creek sub-watershed, including exclusion of cattle from stream channels, riparian corridor restoration, gully maintenance, and road infrastructure improvements to reduce sediment-laden runoff from roads. However, as survey access has previously been limited in this sub-watershed, it is recommended that a focused survey be conducted to identify specific fine sediment supply areas and site-appropriate remediation measures. Ideally this survey would also be used to identify measures that may be appropriate to retain fine sediment from the sub-watershed before it enters Santa Rosa Creek.

4.3.3 Implement Cambria drainage study recommendations

Both the 1999 and 2004 drainage studies conducted in Cambria's residential neighborhoods indicated that storm water is not being adequately planned for or managed, and warned that storm water issues can be expected to worsen if development continues in the Cambria area, unless meaningful steps are taken to plan for and address road- and home lot-related storm water runoff (USDA NRCS 1999, RMC 2004). These studies include detailed maps of problem areas, and recommend projects to improve storm water runoff capture and conveyance. It is recommended that these recommendations be implemented on a voluntary basis by existing property owners, and be required for newly proposed developments, either by the developer or coordinating local entity. The USDA NRCS (1999) report and maps are available for review at the Greenspace office: 4251 Bridge St, Cambria, CA 93428. The San Luis Obispo County Flood Control and Water Conservation District report and maps (RMC 2004) are available on-line: http://www.slocountydrainagestudies.org/

4.4 Conserve and Protect Open Spaces and Existing Land Uses

Conserving existing open space and land uses in the watershed will help address one of the critical issues in the watershed: the threat of land use change on fine sediment production, water demand, and the deleterious effects of urban development (e.g., increased impervious surfaces, contaminated runoff, non-native invasive species introductions, and encroachment of floodplains and the riparian corridor). This can be done via conservation easement, in which the current landowner retains ownership but is compensated for potential restrictions on land use, or fee-title purchase. If property with water rights is purchased, then these recommendations can also serve to increase summer and fall instream flows. Two focal areas for conservation efforts, to best protect aquatic habitat conditions in the watershed, are described below. TLCSLOC (2010) provides additional details on the conservation easement and fee-title purchase options that are relevant to landowners in the watershed.

4.4.1 Conserve undeveloped floodplains

Development near rivers and streams necessitates or facilitates many of the elements that degrade the riparian corridor and aquatic ecosystem, such as polluted runoff, increased runoff and decreased percolation from paved surfaces, rip-rap and other bank protection measures, decreased riparian vegetation, invasion by non-native species, and frequently levees to protect developed areas from high flow events. Floodplains also provide important habitat for a number of terrestrial and semi-aquatic species, such as Pacific pond turtle, California red-legged frog, and two-striped garter snake. To prevent further degradation of the Santa Rosa Creek riparian corridor and aquatic ecosystem, it is recommended that undeveloped floodplains, particularly along the lower creek where few remain and the middle reaches where the floodplains are undeveloped, be conserved and floodplain-compatible land uses maintained. For example, the left-bank floodplain between the Burton Street Bridge and Highway 1 is currently undeveloped and supports hiking trails and related recreational activities. Keeping infrastructure and/or more developed land uses away from the creek in this area will help conserve existing floodplain conditions and service, likely contribute to restoration efforts, and prevent further constraints on riparian and aquatic conditions in the future.

4.4.2 Conserve land uses in the upper watershed

The subdivision of large parcels, which are generally located in the upper watershed, is likely to result in land use changes in the subsequent smaller parcels. If these future land uses remove vegetation (both upslope and riparian), change hillslope topography, or alter runoff patterns, there is the potential that gully and rill erosion could be reinitiated with a subsequent increase in fine sediment delivery to watershed stream channels. Retaining large parcels or otherwise conserving existing land uses in the upper watershed would help prevent the degradation of aquatic habitat throughout the watershed.

4.5 Increase Woody Debris Supply and Retention

Lack of available summer and winter habitat was identified as a factor limiting the population of steelhead. Summer habitat for steelhead has been degraded in part by a disruption of the channel forming processes that form pools, including, but no limited to, a lack of woody debris that typically forms pools where steelhead and other aquatic species can over-summer, provides instream cover and protection from predators, and contributes to the food supply. This lack of woody debris also contributes to the degradation of winter habitat for steelhead. In addition to finding refuge from high flows in the interstitial spaces among cobbles and boulders, steelhead

depend on the slower-water refuge areas provided by large woody debris, boulders and other instream cover, and undercut banks during high flow events. In Mediterranean-climate watersheds, large woody debris, which is generally composed of hardwoods such as bay, alder, sycamore, and willow trees greater than six inches in diameter at breast height, is frequently lacking as a result of overall riparian vegetation loss and its removal when it does enter streams (Opperman 2002).

Recommendations to restore the riparian corridor (Section 4.2) will, over time, help to increase the supply of natural large woody debris to the watershed. In conjunction with riparian restoration, education efforts are recommended to help landowners develop a complete understanding of the role large woody debris plays in the riparian ecosystem, and the measures that can be taken to avoid conflicts between large woody debris recruitment and retention and adjacent land uses due to the real and perceived threats from large woody debris on streambank infrastructure and flood risk. The combination of increased large woody debris supply and retention in stream channels contributes to restoring natural ecosystem function and providing long-term and sustainable summer and winter habitat for steelhead.

Riparian restoration is a long term action that will take upwards of a decade before the large woody debris it supplies begins to contribute to the improvement of summer and winter habitat conditions for steelhead. Since the lack of both over-summer and over-winter habitat may be limiting the steelhead population in the Santa Rosa Creek watershed, it is highly recommended that large woody debris in the stream be left where it is found or to manipulate its orientation in its current location. In other cases, it may be appropriate for large woody debris structures to be incorporated into other types of instream projects, such as bank stabilization projects (see Section 4.2.3). Riparian tree species that are native to the watershed, such as alder, bay, sycamore, and willows are appropriate and have been documented, particularly when in multiple log configurations, to effectively form pool habitat and provide instream cover (Opperman 2002). Any project in the watershed that incorporates large woody debris structures needs to be carefully and strategically planned and implemented to minimize unintended consequences on adjacent and/or downstream property, maximize the sustainability and effectiveness of the project in providing winter and summer habitat, and be consistent with the type of woody debris that would occur naturally in Santa Rosa Creek.

4.6 Remove Barriers to Fish Passage

Physical fish passage barriers can restrict adult and juvenile steelhead to the poorer quality spawning and rearing habitats in the lower reaches of Santa Rosa Creek, and may limit the steelhead population if/when this occurs in successive years. Culverts at Taylor and Curti creeks, and elsewhere, not only impede steelhead access to these tributaries, but they interrupt the supply of coarse sediment and large woody debris which is essential to maintaining suitable winter and summer rearing habitat for steelhead. Removal or modification of these culverts is recommended if there is sufficient quantity and quality steelhead habitat upstream. In addition to improving fish passage, sediment and large woody debris transport would be improved under the full range of flow conditions. Recommendations to determine additional actions that could be taken to improve passage conditions in the middle reaches of Santa Rosa Creek, and to assess the severity of potential passage barriers in the Perry/Green Valley Creek sub-watershed are included in Section 4.7 below.

4.7 Fill Key Data Gaps

The Watershed Synthesis and Steelhead Limiting Factors Analysis identified a number of key data gaps that limit the understanding of watershed conditions and processes, the identification of factors potentially limiting steelhead, and the ability to develop effective actions to enhance watershed conditions and address steelhead limiting factors. Ideally the results of the investigations described below will be used to test the hypotheses of steelhead limiting factors, such that hypotheses are accepted, rejected, or refined, based on new understanding of the system.

4.7.1 Monitor adult steelhead population

Adult returns are usually considered the best indicator of population status. However, there are currently no robust estimates of adult abundance in Santa Rosa Creek. Due to the difficulty in monitoring steelhead spawning in creeks with small steelhead populations and dispersed spawning habitat, CDFG recommends the use of traps, weirs, and/or video or sonar detection systems to provide an absolute count of migrating adults (Adams et al. 2011).

4.7.2 Identify steelhead instream flow requirements

While the recommendations in Section 4.1 above will contribute to the maintenance of summer and fall instream flows, better understanding the site-specific instream flow requirements for key steelhead life history stages is essential for developing and planning specific actions. Therefore, an analysis of how much flow is required to maintain adequate summer and fall rearing habitat for age 1+/2+ steelhead (e.g., passage over shallow riffles and connectivity between pools, and suitable water temperatures) and summer invertebrate production is recommended. The results of this assessment would refine the understanding of the specific locations and ways that instream flows limit the steelhead population and can be used to identify minimum instream flow goals in specific parts of the watershed that can then guide the type and number of actions taken to maintain summer and fall instream flows. In addition, this survey, if conducted in the winter can be used to identify minimum flow needs to facilitate migration over shallow riffles. The flows needed for both adult and juvenile steelhead migration have been identified for lower Santa Rosa Creek (D. W. Alley & Associates 1993), but the previous study did not include the intermittent portion of the middle reach situated upstream of the Perry Creek confluence, or upstream of Mammoth Rock where the stream is perennial most years (Figure 2-8). It is recommended that any identification of instream flow requirements be accompanied by an analysis of available stream flow data in order to evaluate the extent to which instream flow requirements for fish passage and/or summer and fall rearing habitat are or are not being met.

4.7.3 Assess lagoon habitat quality and steelhead smolt growth in and outside the lagoon

The degree to which steelhead use the lagoon for rearing, and that the lagoon contributes to steelhead growth, is uncertain (Nelson et al. 2009). As stated previously by CDFG, it is recommended that studies be implemented to document juvenile steelhead use of the lagoon to better understand the link between juvenile steelhead production/carrying capacity in the creek and lagoon, and evaluate steelhead growth patterns under a range of water-year types. These surveys would ideally include the timing and extent of steelhead use of the lagoon, timing and duration of emigration/immigration as related to sandbar closure and instream flow, growth rates in and upstream of the lagoon, and population estimates. Combined with strategic monitoring of water temperature, DO, and salinity under varying flow conditions, these studies can be used to

evaluate the suitability of the lagoon for rearing under different water-year types and identify specific actions for enhancing lagoon quality and optimizing steelhead lagoon rearing.

4.7.4 Assess flows through the middle reaches of Santa Rosa Creek

These reaches (approximately stream mile 6.5 to 8) generally run dry each summer, restricting connectivity between steelhead rearing habitat, and, in dry winters, are hypothesized to impede upstream migration of spawning steelhead (Nelson et al. 2009). Due to the low gradient and position in the watershed, these reaches are the natural depositional area for sediments transported from the upper watershed and, in combination with land use changes, result in a wide, undefined floodway and highly pervious substrates. Additional survey work and analysis are recommended to better understand the natural vs. human factors controlling instream flows through these reaches and determine what, if any, other actions would be appropriate to increase the capacity of these reaches to maintain minimum instream flows in the summer and improve upstream migration conditions during dry winters.

4.7.5 Estimate juvenile steelhead abundance

There are currently extensive data on fall abundance of juvenile steelhead in Santa Rosa Creek. While fall abundance data is useful for understanding annual abundance trends, it does not allow the direct assessment of summer habitat limitations, which is a key step in understanding factors limiting the steelhead population in the watershed. Developing reach-specific abundance estimates in the early summer, in addition to the fall, would allow evaluation of both over-winter and over-summer survival of both YOY and older juveniles, and potentially help identify over-winter and/or over-summer habitat limiting factors that may be addressed through restoration. Ideally this would be conducted for several years to help understand the dependence of winter and summer survival on variations in water quantity and flow dynamics. It is recommended that any juvenile monitoring be done according to the protocols described in CDFG's recent California Coastal Salmonid Population Monitoring Strategy, Design, and Methods report (Adams et al. 2011).

4.7.6 Assess mercury uptake in the aquatic food chain

It is unknown to what extent or even if the high levels of mercury that have been detected in sediments in Curti and Santa Rosa creeks are accumulating in the aquatic food chain and/or potentially affecting steelhead populations. To better understand the degree of mercury contamination in the watershed and potentially garner funding for remediation efforts, it is recommended that a focused study of mercury be conducted in the watershed. A well designed study would include sites upstream of, at, and downstream of the mercury mine former mill site off of Curti Creek, as well as other known mercury mine locations in the watershed, to determine natural background levels of mercury and patterns of mercury contamination downstream. Such a study would also include water, sediment, and resident aquatic organism (e.g., benthic invertebrates and/or small resident fish) samples that are tested for total mercury and methylmercury.

4.7.7 Assess the Perry/Green Valley Creek sub-watershed

It is unknown if the Perry/Green Valley Creek sub-watershed is accessed or used by steelhead, or what the aquatic habitat conditions are like. Given the size of this sub-watershed and the potential for steelhead habitat, it is recommended that the assessment include, but not be limited to, geomorphic, hydrologic, and biological (e.g., aquatic habitat conditions, fish passage, and

steelhead use) surveys. Knowing the limiting factors potential for steelhead in this sub-watershed would be an important first step towards understanding the relative importance of this sub-watershed for steelhead.

4.7.8 Continue and expand citizen water quality monitoring

The benthic macroinvertebrate and first flush sampling, which was done in coordination with the broader Monterey Bay Sanctuary Citizen Watershed Monitoring Network, conducted for the development of this Watershed Management Plan help characterize just one year of water quality conditions in lower Santa Rosa Creek. Multiple, and ideally continuous, years of sampling and additional sampling sites in the upper watershed, are needed to better understand temporal and spatial trends in water quality conditions. If and when temporal and spatial trends are recognized, these can be used to help identify emerging risks to water quality and aquatic species, pollutant sources, and, subsequently, appropriate best management practices to minimize or prevent pollutants from entering waterways.

4.8 Reduce Mercury Supply

Due to the high potential for mercury to affect human health and aquatic organisms and the fact that methlymercury—the most bio-available form of mercury—has been detected in the Santa Rosa Creek lagoon, it has been previously recommended that efforts be made to control known sources of mercury in the watershed. These recommendations include erosion control along Curti Creek to prevent mercury-laden sediment from being delivered to the creek and creation of treatment wetlands to retain and accumulate existing mercury in the system, need to be implemented to prevent further mercury contamination.

4.9 Summary of Recommendations

Table 4-1 summarizes the recommendations described above and the primary reason for their inclusion in the Watershed Management Plan (e.g., near-term steelhead habitat restoration, long-term watershed enhancement, etc.). The recommendations are listed in order of their relative importance to steelhead habitat restoration, but this ranking is not intended to limit the implementation of any recommendation. Appendix D describes a variety of sources of potential funding for implementation of the plan recommendations.

Table 4-1. Summary of recommendations.

Recommendation (Bolded text indicates actions that are of higher priority for steelhead habitat restoration)		Included to Address:		
		Near-term steelhead habitat restoration	**Long-term watershed enhancement**	**Key uncertainties**
4.1.1	**Implement water conservation and reuse strategies**	•	•	
4.1.2	**Construct off-stream closed water storage**	•	•	
4.1.3	**Purchase water rights from willing sellers for instream flows**	•	•	
4.1.4	**Conduct stream gauging and develop an updated water budget**		•	•
4.1.5	Reduce future municipal groundwater pumping			
4.2.2	**Revegetate degraded streambanks**		•	
4.2.1	**Manage grazing to reduce impacts to the riparian corridor**		•	
4.2.3	**Minimize the need for bank protection**		•	
4.2.4	Treat non-native invasive species		•	
4.3.1	**Maintain roads to decrease hillslope and streambank erosion**		•	
4.3.2	**Reduce and/or retain fine sediment delivery from the Perry/Green Valley Creek sub-watershed**		•	
4.3.3	Implement Cambria drainage study recommendations		•	
4.4.1	**Conserve undeveloped floodplains**		•	
4.4.2	**Conserve land uses in the upper watershed**			
4.5	**Increase woody debris supply and retention**	•	•	
4.6	**Remove barriers to fish passage**		•	
4.7.1	**Monitor adult steelhead population**			•
4.7.2	**Identify steelhead instream flow requirements**		•	•
4.7.3	**Assess lagoon habitat quality and steelhead smolt growth in and outside the lagoon**	•		•
4.7.4	Assess flows through the middle reaches of Santa Rosa Creek	•	•	
4.7.5	Estimate juvenile steelhead abundance			•
4.7.6	Assess mercury uptake in the aquatic food chain			•
4.7.7	Assess the Perry/Green Valley Creek sub-watershed			•
4.7.8	Continue and expand citizen water quality monitoring			•
4.8	Reduce mercury supply		•	

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6.2 Personal Communications

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Kendall, G. 2010. Cambria resident/Santa Rosa Creek Watershed Management Plan technical advisor. Personal communication with R. Hawley, Executive Director, Greenspace – the Cambria Land Trust.

Ochs, A. 2009. Volunteer researcher, San Luis Obispo County Historical Society. Personal communication with G. Leverich, Geomorphologist, Stillwater Sciences.

Rathbun, G. 2010. Honorary Fellow and Research Associate, California Academy of Sciences, Department of Ornithology and Mammalogy. Personal communication with Z. Diggory, Ecologist, Stillwater Sciences.

Smith, M. 2010. Cambria resident/Santa Rosa Creek Watershed Management Plan stakeholder. Personal communication with R. Hawley, Executive Director, Greenspace – the Cambria Land Trust.

Soto, S. 2010. Cambria resident/Santa Rosa Creek Watershed Management Plan stakeholder. Personal communication with R. Hawley, Executive Director, Greenspace – the Cambria Land Trust.

Spina, A. 2010. Fisheries Biologist, NOAA Fisheries Southwest Regional Office/Santa Rosa Creek Watershed Management Plan technical advisor. Personal communication via peer review comments to Z. Diggory, Ecologist, Stillwater Sciences.

Walgren, M. 2010. Environmental Scientist, California State Parks San Luis Obispo Coast District. Personal communication with Z. Diggory, Ecologist, Stillwater Sciences.

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Appendices

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Appendix A

Geomorphic Assessment of Santa Rosa Creek Watershed

(provided as separate document)

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Appendix B

Santa Rosa Creek BMI Sampling

(provided as separate document)

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Appendix C

Public Meeting Questionnaire

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Santa Rosa Creek Watershed
Tell Us What You Think

We greatly appreciate your assistance! Please, fill out this form as completely as you can and place in Public Comment Box before leaving. Then, take a raffle ticket and put one half in the bowl to be eligible for the drawing. (If you need more space for answers, please use the other side of the page.)

1. What are your concerns about the creek and watershed?

2. Do you know of an area in the creek that is in need of maintenance? *Example: bank stabilization, erosion, or trash pickups.*

3. Would you share any stories or historic photos you might have about steelhead or unusual occurrences that that have occurred related to Santa Rosa Creek? We can contact you if you prefer to provide contact info.

4. Please rank the following items in terms of your assessment of their importance with 1 as highest priority and 5 as lowest priority. There are two blank boxes to write in your own priorities.

	1	2	3	4	5
Improve water quality	1	2	3	4	5
Improve water quantity	1	2	3	4	5
Restore and protect riparian habitat for native plants and animals	1	2	3	4	5
Improve natural conditions for people living in the watershed	1	2	3	4	5
Foster community stewardship of, and education about, the watershed such as volunteering for projects	1	2	3	4	5
Reduce sediment delivery into the creek	1	2	3	4	5
	1	2	3	4	5

Contact Information (optional)

Name: _____

Street Address: _____

City: _____ Zip: _____

Phone _____
Email: _____
Interest Representing: _____

☐ Mailing List ☐ Volunteer Water Monitoring ☐ Special Events – creek clean up

Santa Rosa Creek Watershed
Compiled Questionnaire Information
Public Meeting January 19, 2010

1. What are your concerns about the creek and watershed?
   - Improving quality of resources through cooperation of community/landowners
   - Ag run-off, human caused pollution, illegal dumping, invasive species, sewage impacts
   - That it becomes a healthy system that supports wildlife and public enjoyment of the environment
   - Restore and maintain creek, tributaries and lagoon for steelhead and other wildlife
   - Deforestation, defoliation, top-soil erosion, earth subsidence, deterioration of air and water resources
   - Hope for cooperative effort that results in a healthy watershed
   - Balanced use between Santa Rosa and San Simeon Creeks
   - Use, pollution
   - Taking too much water out and loss of healthy habitat
   - Public health; maintain healthier habitat conditions; viability for diverse species; over-development
   - Sustainable management of water for environment and people; enhance the productivity of ecosystem services of SR Creek Watershed
   - Want more water flow and better water quality to support more wildlife
   - That there be enough water for all of us
   - Interfering with creek hydrology; desal; erosion
   - Steelhead; mercury
   - Sediment load/erosion; hydrologic roughness
   - Amount of overgrowth that has been allowed to remain along the banks; this is going to cause another flood when it all backs up behind Windsor Bridge
   - Overpopulation; building near the creek banks

2. Do you know of an area in the creek that is in need of maintenance? *Example: bank stabilization, erosion, or trash pickups.* If so, please indicate location.
   - Along Fiscalini Ranch Reserve; periodic trash pick up; invasive species removal along streambanks
   - Ferasci Bridge is a barrier to steelhead use; bridge should be reconstructed to allow passage
   - Maintenance is what degrades wildlands
   - Along Hwy. 1 to Burton Dr. trash, weeds, erosion near Hwy. 1 Bridge

- Burton Drive Bridge erosion under and around bridge; sediment falling from steep hillsides on Burton Dr. and increased grading activity on the Rodeo grounds

3. Would you share any stories or historic photos you might have about steelhead or unusual occurrences that that have occurred related to Santa Rosa Creek? We can contact you if you prefer to provide contact info.

   We may contact people who offered stories/photos directly.

4. Please rank the following items in terms of your assessment of their importance with 1 as high priority and 5 as low priority. First number is priority rank; second number is how many responded to that ranking.

Protect stream side archeological sites*	1/1	2	3	4	5
Improve water quality	1/14	2/4	3/1	4/1	5/0
Increase water quantity	1/9	2/5	3/4	4/2	5/0
Restore and protect riparian habitat for native plants and animals	1/11	2/6	3/2	4/0	5/2
Improve natural conditions for people living in the watershed for recreational activities	1/0	2/3	3/10	4/3	5/4
Increase education about the importance of the watershed	1/10	2/6	3/3	4/0	5/1
Foster community stewardship of the watershed such as through volunteering for projects	1/9	2/5	3/4	4/0	5/2
Reduce sediment delivery into the creek	1/12	2/1	3/5	4/2	5/0
Stop fire district campaign*	1/1	2	3	4	5
Monitor water quality (chemical) at least 4 times each year*	1/1	2	3	4	5
Clear sides of banks*	1/1	2	3	4	5
Steelhead enhancement*	1/1	2	3	4	5

*write-ins
Total submitted = 21

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Appendix D

Funding Resources

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California Department of Fish and Game Fisheries Restoration Grant Program (FRGP)
http://www.dfg.ca.gov/fish/Administration/Grants/FRGP/

FRGP was established in 1981 in response to rapidly declining populations of wild salmon and steelhead trout and deteriorating fish habitat in California. This competitive grant program has invested over $180 million to support projects from sediment reduction to watershed education throughout coastal California. Contributing partners include the California Department of Fish and Game (CDFG), federal and local governments; tribes, water districts, fisheries organizations, watershed restoration groups, the California Conservation Corps, AmeriCorps, and private landowners.

San Luis Obispo County Fish and Game Commission Fines Committee
Contact: Robert Cone (805) 781-5024

Each year as part of its budget process, the San Luis Obispo County Board of Supervisors approves a lump sum budget for the Fish and Game Fine Commission. The committee meets to develop a detailed listing of recommended projects for the coming fiscal year. The listing is then submitted to the Board for approval.

CalTrans Environmental Enhancement and Mitigation Program (EEM)
http://www.dot.ca.gov/hq/LocalPrograms/EEM/homepage.htm

EEM is provided by Streets and Highways Code Section 164.56 and authorizes the allocation of up to $10 million each year for grants to mitigate the environmental impacts of modified or new public transportation facilities.

San Luis Obispo Integrated Regional Water Management Plan (IRWMP)
http://www.slocountywater.org/site/Frequent%20Downloads/Integrated%20Regional%20Water%20Management%20Plan/index.htm

The Integrated Regional Water Management (IRWM) Program is intended to promote and practice integrated regional water management to ensure sustainable water uses, reliable water supplies, better water quality, environmental stewardship, efficient urban development, protection of agriculture, and a strong economy.

Wildlife Conservation Board Habitat Enhancement and Restoration Program (HERP)
http://www.wcb.ca.gov/HERP/grants.html

After the Wildlife Conservation Board (WCB) was created by the Wildlife Conservation Law of 1947, it was given the authority to acquire and restore California lands to protect wildlife values and to provide wildlife-oriented public access. The Habitat Enhancement and Restoration Program (HERP) was WCB's first program and incorporated all restoration projects until new restoration programs were first initiated in 1990. Over the last 20 years, there have been at least eight specific new programs added to the WCB's mandate that fund and target certain types of habitat restoration projects that historically fell under the HERP. While the program is not as active as it once was, it still effectively covers important habitat enhancement and restoration projects that fall outside the criteria of the other habitat restoration programs.

California State Coastal Conservancy

http://scc.ca.gov/category/grants/

To achieve its goals, the Coastal Conservancy may award grants to public agencies and nonprofit organizations that qualify under Section 501(c)(3) of the United States Internal Revenue Code and whose purposes are consistent with Division 21 of the California Public Resources Code (commencing with section 31000). Some examples of the kinds of projects the Coastal Conservancy may fund include trails and other public access to and along the coast, natural resource protection and restoration in the coastal zone or affecting coastal areas, restoration of coastal urban waterfronts, protection of coastal agricultural land, and resolution of land use conflicts.

U.S. Fish and Wildlife Service Fisheries Operational Needs System Database for National Fish Passage Program Funds

Contact: Donald Ratcliff (209) 334-2968 ext. 409

Millions of culverts, dikes, water diversions, dams, and other artificial barriers have been constructed to impound and redirect water for irrigation, flood control, electricity, drinking water, and transportation--all changing natural features of rivers and streams. In 1999, the U.S. Fish and Wildlife Service initiated the National Fish Passage Program to work with others to address this problem. The Program uses a voluntary, non-regulatory approach to remove and bypass barriers to aquatic species movement. The Program addresses the problem of passage barriers on a national level, working with local communities and partner agencies to restore natural flows and fish migration. The Program is administered by National and Regional Coordinators, and delivered by Regional Fish and Wildlife Management Assistance Offices.

U.S. Fish and Wildlife Service Partners in Fish and Wildlife Program

http://www.fws.gov/partners

The mission of the Partners Program is to efficiently achieve voluntary habitat restoration on private lands through financial and technical assistance for the benefit of Federal Trust Species.

National Oceanic and Atmospheric Administration (NOAA) Southwest Region

http://www.habitat.noaa.gov/funding/southwest.html

NOAA Restoration Center's Community-based Restoration Program invests funding and technical expertise in high-priority habitat restoration projects that instill strong conservation values and engage citizens in hands-on activities. Through the program, NOAA, its partners, and thousands of volunteers are actively restoring coastal, marine, and migratory fish habitat across the nation. The NOAA Restoration Center staff helps to identify potential projects, strengthen the development and implementation of habitat restoration activities within communities, and generate long-term national and regional partnerships to support community-based restoration efforts across a wide geographic area.

Upper Salinas-Las Tablas Resource Conservation District

http://us-ltrcd.org/

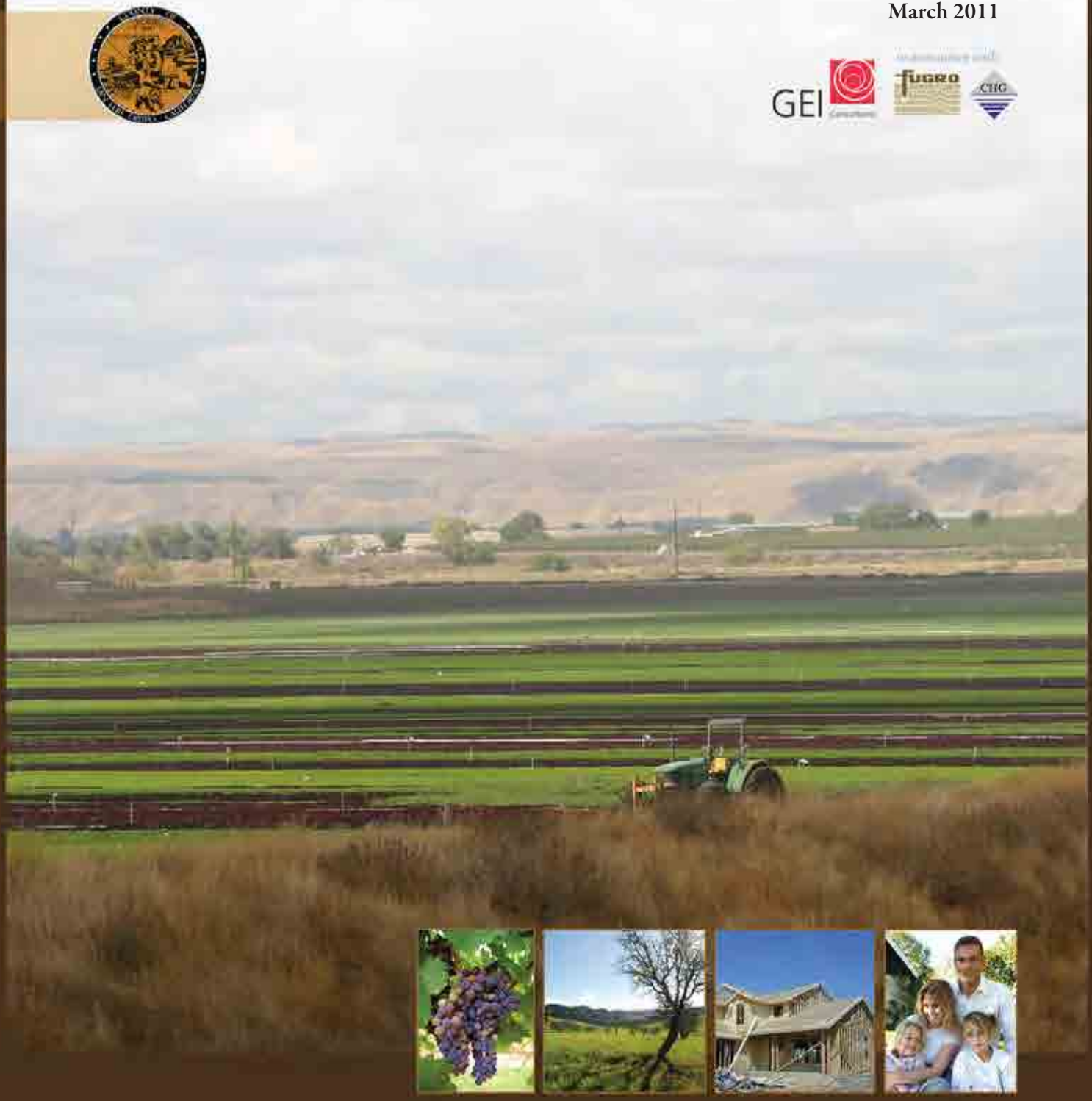
The Upper Salinas-Las Tablas Resource Conservation District (RCD) serves the local community with its programs in watershed management, restoration, research and education and works with public and private landowners to conserve natural resources throughout the Upper Salinas River Watershed and surrounding environments. The RCD can coordinate with the USDA Natural Resources Conservation Service to bring cost-share programs to a project in order to make restoration projects cost effective.

Private Foundations

Fund For Wild Nature	http://www.fundwildnature.org/
Doris Duke Charitable Foundation Wildlife Action Opportunities Fund	http://www.wcs.org/wildlifeopportunity
Lindbergh Foundation	http://www.lindberghfoundation.org/
Disney Wildlife Conservation Fund	http://www.dwcf-rfp.com/
Waste Management	http://www.wm.com/community/giving.asp
Environmental Grantmakers Association	http://www.ega.org/funders/index.php
Acorn Foundation	http://www.commoncounsel.org/AcornFoundation
California Watershed Funding Database	http://www.calwatershedfunds.org/
Directory of Watershed Resources	http://www.efc.boisestate.edu/watershed/
Conservation grants	http://www.conservationgrants.com/water.htm
EPA Catalog of Federal Funding Sources for Watershed Protection	http://cfpub.epa.gov/fedfund/
Databases of Funding Opportunities	http://www.epa.gov/owow/funding/databases.html
Ben and Jerry's Foundation	http://www.benjerry.com/company/foundation/
Gordon and Betty Moore Foundation	http://www.moore.org/
Henry P. Kendall Foundation	http://www.kendall.org/index_flash.html
Rivers Foundation	http://riversfoundation.org/rfa/about/
Norcross Wildlife Foundation	http://www.norcrossws.org
Frost Foundation	http://www.frostfound.org/Pages/grantapp.html
Fish America	http://www.fishamerica.org/grants/index.html
American Rivers	http://www.americanrivers.org/our-work/restoring-rivers/dams/noaa-grants-program.html
Global Restoration Network	http://www.americanrivers.org/our-work/restoring-rivers/dams/noaa-grants-program.html
Trout Unlimited	http://www.tucalifornia.org

Paso Robles Groundwater Basin Management Plan

March 2011



Paso Robles Basin Groundwater Management Plan

Submitted to
Paso Robles Groundwater Basin –Groundwater Advisory Committee

Date: February 2011 V2.0
Project No: 083720

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Abbreviations and Acronyms

Basin	Paso Robles Groundwater Basin
BMOs	Basin Management Objectives
CASGEMs	California Statewide Groundwater Elevations Monitoring Program
CCVT	Central Coast Vineyard Team
City	City of Paso Robles
County	San Luis Obispo County
CSAs	County Service Areas
District	San Luis Obispo County Flood Control and Water Conservation District
DPH	California Department of Public Health (formerly Department of Health Services)
DPW	County Department of Public Works
DWR	California Department of Water Resources
GAC	Groundwater Advisory Committee
GMAs	Groundwater Management Activities
GMP	Groundwater Management Plan
IRWMP	Integrated Regional Water Management Plan
M&I	Municipal and Industrial
MCWRA	Monterey County Water Resources Agency
MOU	Memorandums of Understanding
msl	mean sea level
NRCS	Natural Resources Conservation Service
Plan	Paso Robles Groundwater Basin Management Plan
PRIOR	Paso Robles Imperiled Overlying Rights
PRWCA	Paso Robles Wine Country Alliance
RCS	Resource Capacity Study
RMS	Resource Management System
State	State of California
SWP	State Water Project

TDS	total dissolved solids
UWMP	Urban Water Management Plan
WRAC	Water Resource Advisory Committee
WPAs	Water Planning Areas

1 Introduction

1.1 Introduction

The Paso Robles Groundwater Basin (Basin) is located in northern San Luis Obispo County (County) and southern Monterey County and was described in the 1958 California Department of Water Resources (DWR) Bulletin 118, San Luis Obispo County Investigation. As part of the efforts to map the groundwater basins in the State of California (State) presented in Bulletin 118, DWR identified the Paso Robles Area Groundwater Subbasin of the Salinas Valley Groundwater Basin and designated it as Basin Number 3-4.06. The Basin boundary was later updated in the Paso Robles Groundwater Basin Study (2002) and is shown on Figure 1-1.

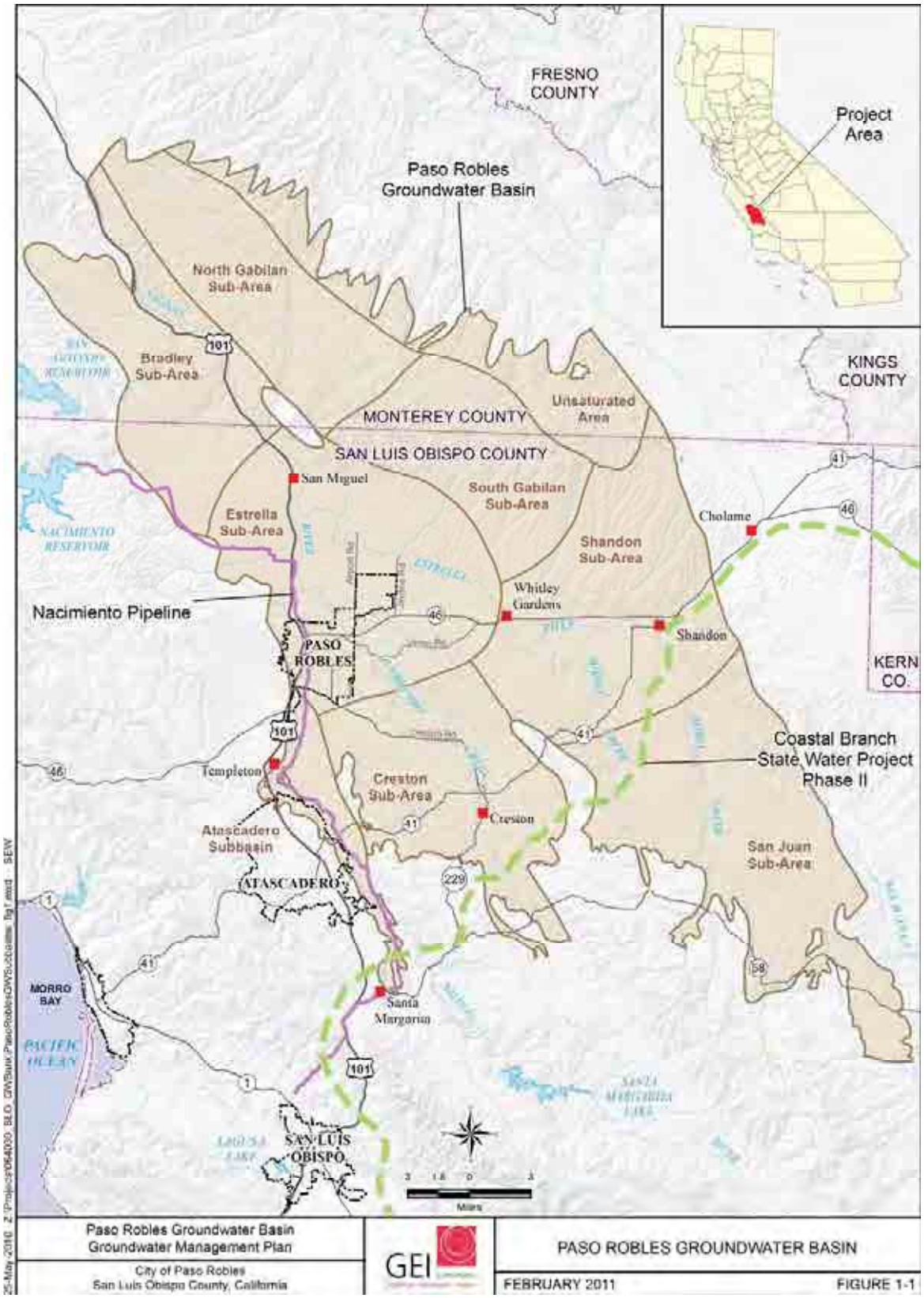
The Basin supplies water for 29 percent of the County's population and an estimated 40 percent of the agricultural production of the County. The municipal and industrial (M&I), domestic, and agricultural demands in the Basin currently rely exclusively on groundwater (including the underflow of streams). The M&I water demands include the cities of Paso Robles and Atascadero, the communities of Templeton, Shandon, Creston, and San Miguel, Bradley, Camp Roberts, and the small community systems in Whitley Gardens and Garden Farms. Individual domestic groundwater users and isolated subdivisions are located throughout the Basin, often in the more rural areas dispersed among the agricultural areas. Agricultural water users constitute an estimated 67 percent of the pumpage in the Basin and are concentrated on the alluvial valleys of the streams and rivers and along the Highway 46 corridor.

Over the past decade, the San Luis Obispo County Flood Control and Water Conservation District (District) and the City of Paso Robles (City) have worked with other pumpers in the Basin to begin a more organized approach to groundwater management as described in Section 2.

The Basin Study (Fugro, 2002) estimated the volume of groundwater storage along with basin inflows and outflows. These values were used to compile a hydrologic budget (water balance) and establish a perennial yield (also called the safe yield) for the Basin at 94,000 acre-feet per year. In 2005, the perennial yield was modified to 97,700 acre-feet per year based on additional analysis.

Based on a recent (Todd, 2007) monitoring report, the Basin was not at the safe yield although some areas were experiencing significant declines in groundwater elevations. A later study completed in 2009 suggests groundwater pumping was approaching the safe yield of the Basin, which led to the recommendation to do a groundwater management plan.

Figure 1-1. Paso Robles Groundwater Basin



The Resource Capacity Study prepared by the San Luis Obispo County Planning Department in November 2010 states that the Basin is near or at perennial yield, and contains land use and water use monitoring and conservation recommendations within the authority of the County and District to help ensure the sustainability of the Basin into the future.

The Paso Robles Basin Groundwater Management Plan was prepared coincident with the preparation of the Resource Capacity Study as well as other ongoing studies to develop a stakeholder-driven voluntary plan to provide a framework for future groundwater management activities. This project was funded by a grant from the Local Groundwater Assistance Act of 2000 (California Water Code Section 10795 et seq) to provide grants to public agencies to conduct groundwater studies or to carry out groundwater monitoring and management activities. Local Groundwater Assistance Grants (AB303) are awarded by the California Department of Water Resources (DWR). Funding was available in 2007-2008 for AB303 grants.

The purpose of this Plan is to develop a common understanding of the groundwater issues and management opportunities in the Basin and identify and support projects such as conjunctive use, recycled wastewater, and demand management, which will improve groundwater management. Following development of the Plan, the goal is to implement the activities identified in the Plan to achieve the Basin Management Objectives that are identified in the Plan. Figure 1-2 shows some of the interconnectivity of the groundwater management activities that are part of groundwater management planning and implementation. The approach illustrated in Figure 1-2 was applied during the development of this Plan.

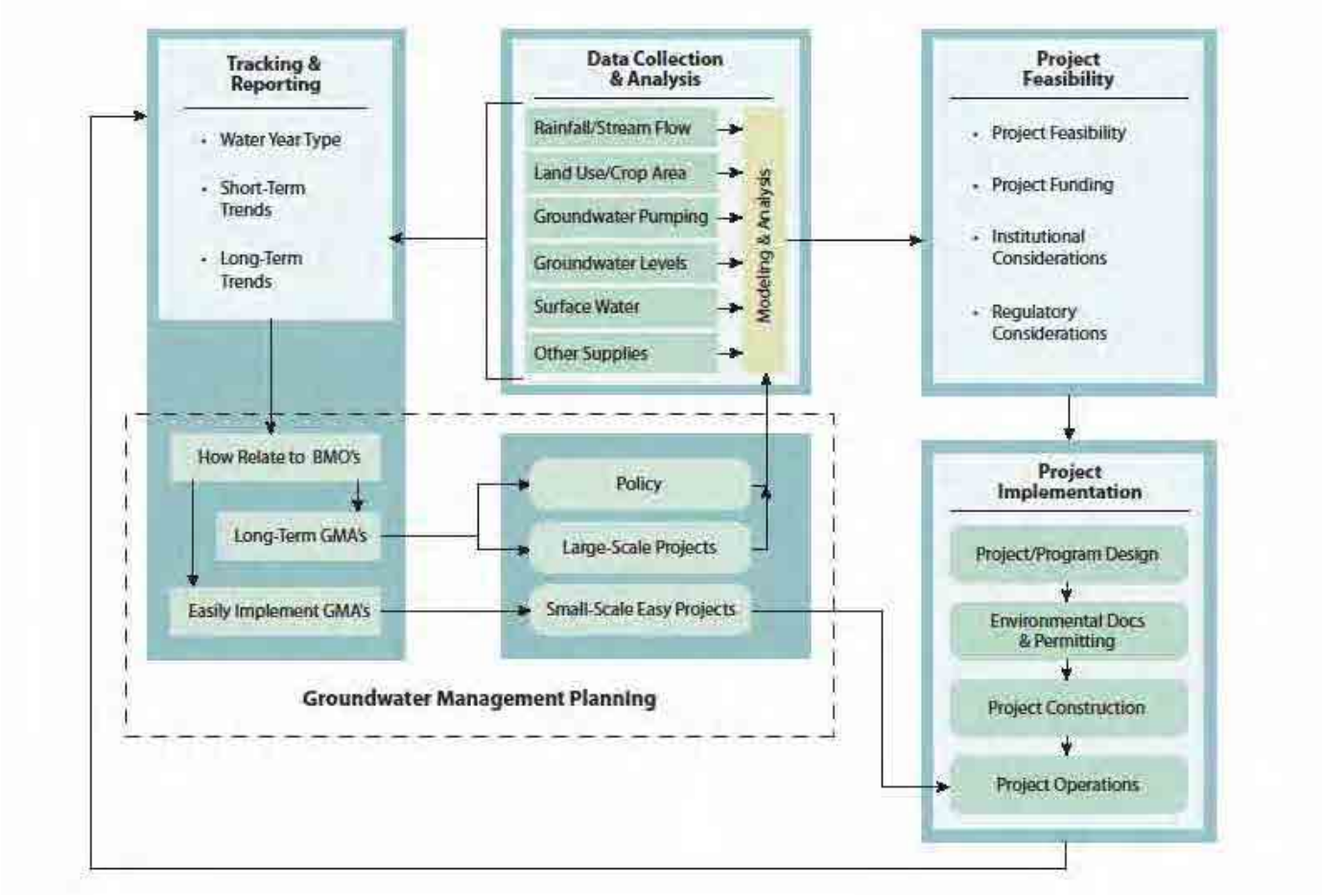
Groundwater management requires groundwater level and other data collected and analyzed on a routine basis (typically annually) to establish the current conditions of the groundwater basin. Groundwater data is tracked and reported to agencies, interested parties, and stakeholders.

This information is also used to establish groundwater management goals and objectives (referred to as Basin Management Objectives [BMOs]) and identify specific actions (referred to as Groundwater Management Activities [GMAs]).

Depending on the difficultly and complexity of GMAs, additional analysis may be needed to support their implementation. Relatively simple projects that are feasible and provide benefit may be able to be implemented easily, while more complex, large, expensive projects or projects that include multiple agencies may require additional analysis and studies to establish their feasibility and quantify their benefits.

The effects of these projects and other groundwater management activities are expected to result in changed groundwater conditions which are monitored and reported to the agencies, interested parties, and stakeholders.

Figure 1-2. Groundwater Management in the Paso Robles Groundwater Basin



1.2 Regional Groundwater Management Plan Area

The Basin was first formally defined by the California Department of Water Resources (DWR, 1958). In 1979, the DWR published a detailed investigation of the San Luis Obispo County portion of the Basin (DWR, 1979).

The Basin encompasses an area of approximately 505,000 acres (790 square miles). The Basin ranges from the Garden Farms area south of Atascadero to San Ardo in Monterey County, and from the Highway 101 corridor east to Shandon (Figure 1-1). Most of the Basin is hydraulically connected by thick sedimentary sections. The Basin is divided into smaller subareas based on water quality, source of recharge, groundwater movement, and the contours of the base of permeable sediments.

The Atascadero Subbasin is defined as that portion of the Basin west of the Rinconada fault. Between Atascadero and Creston, the Rinconada fault juxtaposes less permeable Monterey Formation rocks with the Paso Robles Formation basin sediments. South of the City of Paso Robles, the Paso Robles Formation is found on both sides of the Rinconada fault; however, the fault zone is believed to form a leaky barrier that restricts flow from the Atascadero

Subbasin to the main part of the Basin. As a result of this, the Atascadero Subbasin is considered a hydrologically distinct subbasin within the Basin. The Rinconada Fault does not act as a hydraulic barrier to groundwater flow in the Salinas River Alluvium. As such, groundwater flow in the Alluvium is continuous along the stretch of the Salinas River that traverses the entire Basin. The Atascadero Subbasin encompasses the Salinas River corridor area south of Paso Robles and includes the communities of Garden Farms, Atascadero, and Templeton.

The western boundary of the Basin roughly follows Highway 101 from Santa Margarita northward to Hames Valley. The eastern boundary follows a rough line from Highway 58 in the San Juan Creek area northward to Shandon and Cholame. The Basin is downstream of and hydraulically connected by alluvial deposits to the Pozo Groundwater Basin south of the Basin, and to the Cholame Groundwater Basin north of the Basin. The Basin outlet is northwest and downstream of Bradley, where it is hydraulically connected with the Salinas Valley Groundwater Basin.

The Basin was subdivided into subareas in the Phase I Report (Fugro, 2002) as a practical approach to organize the 790 square mile Basin into smaller informal areas (see Figure 1-1) and listed below.

1. Atascadero Subbasin
2. Creston Subarea
3. San Juan Subarea
4. Estrella Subarea
5. Shandon Subarea
6. North Gabilan Subarea
7. South Gabilan Subarea
8. Bradley Subarea

Just north of San Miguel there is an area of basement rock that extends to the ground surface that is not considered part of the groundwater basin. This area is located between the Estrella, North Gabilan, and Bradley Subareas, but is not considered to be part of any of them.

Near the edges of the Basin, the Paso Robles Formation becomes thin, and wells located in these areas may tap the Paso Robles Formation as well as basement rock. Because of this, wells tapping both the Paso Robles Formation and basement rocks may experience different groundwater level conditions than wells tapping only the Paso Robles Formation.

1.3 Existing Groundwater Management Activities

Since 1998, the local agencies and local stakeholders via a public “North County Water Forum” including Monterey County Water Resources Agency have worked in cooperation to complete several projects to support the technical investigations and improve groundwater management in the Basin. These efforts, listed below, demonstrate the interest, support, and

continuing commitment of the individual agencies, stakeholders, and interested parties in protecting the Basin's groundwater resources. Much of the information developed in the efforts was incorporated into the Plan.

- Master County Water Plan (EDAW, 1998)
- Paso Robles Groundwater Basin Study (Fugro West, 2002)
- Monitoring Program Evaluation (Cleath & Associates, 2003)
- Paso Robles Groundwater Basin Study Phase II –Numerical Model Development, Calibration, and Application (Fugro West , 2005)
- Paso Robles Groundwater Basin Agreement (2005)
- San Luis Obispo County Integrated Regional Water Management Plan (San Luis Obispo County Flood Control and Water Conservation District, 2005)
- City of Paso Robles Urban Water Management Plan (Todd Engineers,2007)
- City of Paso Robles Water Resources Plan Integration and Capital Improvement Program (T.J. Cross Engineers, 2007)
- Annual Report on the Paso Robles Groundwater Basin (Todd Engineers, 2007)
- Paso Robles Groundwater Basin Water Banking Feasibility Study (GEI Consultants, Inc., 2007)
- Evaluation of Paso Robles Groundwater Basin Pumping – Water Year 2006 (Todd Engineers, 2009)
- Paso Robles Groundwater Basin Water Balance Review and Update (Fugro, 2010)
- San Luis Obispo County Master Water Plan (Wallace Group,2010, ongoing)
- Peer Review of Paso Robles Groundwater Basin Studies (Gus Yates, 2010)
- Revised Resource Capacity Study – Water Supply in the Paso Robles Groundwater Basin (San Luis Obispo County Planning Department, 2011)

Each of these groundwater management activities is described below.

1.3.1 Master County Water Plan (1998)

This update of the Master Water Plan evaluated 12 distinct "Water Planning Areas" throughout the County, tabulating water demand and published yields of developed water sources for each area. The result of this effort was an overall inventory of how demand matched supply throughout the County, noting priorities for development of supply projects and guidance for the pace of building permit issuance. This proved to be the foundation document that pointed to the need to further study the County's largest water supply – the Paso Robles Groundwater Basin.

1.3.2 Paso Robles Groundwater Basin Study (2002)

In 2002, the Paso Robles Groundwater Basin Study (Basin Study) investigated the hydrogeologic conditions and quantified the water supply capability of the Basin by defining the lateral and vertical extent of the aquifer, groundwater flow and movement, and current water quality conditions. The Basin Study identified the subareas within the Basin and local hydrogeologic settings based upon water quality, source of recharge, groundwater movement, and basin depth.

The Basin Study estimated the volume of groundwater storage along with basin inflows and outflows. These values were used to compile a hydrologic budget (water balance) and establish a perennial yield for the Basin of 94,000 acre-feet per year. Demand at the time was estimated at 82,600 acre-feet per year and is predominantly agricultural demand. The author recommended the development of a numerical groundwater model (described below) to evaluate future hydraulic conditions.

1.3.3 Paso Robles Groundwater Monitoring Program Evaluation (2003)

The County has been monitoring groundwater levels for more than 40 years in the Basin. The Monitoring Program Evaluation was completed to evaluate the efficiency and effectiveness of the County's Groundwater Level Monitoring Program for wells located in the Basin. Based on the final report of the 154 wells in the program, County Public Works employees monitor 99 wells, and 55 wells are monitored by local municipal water company employees (who forward the data to the County's Public Works Department for inclusion in the monitoring program database). The report provides several recommendations for improving the groundwater level measuring program.

1.3.4 Paso Robles Groundwater Basin Study Phase II – Numerical Model Development, Calibration, and Application (2005)

In 2005, a numerical groundwater flow model was developed as a quantitative tool to evaluate future hydraulic conditions of the Basin. The model was used to refine uncertainties in the hydrologic budget and evaluate the Basin's response to current and future water demands with and without supplemental water, including areas of declining water levels. In 2007, the model was used in the Water Banking Feasibility Study (described below) to evaluate potential recharge and water banking projects and identify management practices that could be employed to optimize water use. This effort revised the Basin perennial yield estimate to 97,700 acre-feet per year.

1.3.5 Paso Robles Groundwater Basin Agreement (2005)

The Agreement was entered into on August 19, 2005 by the District, several overlying landowners who have organized as the Paso Robles Imperiled Overlying Rights (PRIOR) group, and the City of Paso Robles and County Service Area No. 16 (collectively referred to as Municipal Users). Since 2005, additional overlying landowners and the San Miguel Community Services District, as a Municipal User, have also signed the Agreement. The Agreement requires the District to declare the Basin to be in a state of overdraft, when appropriate, at which point a period of time is conferred to allowing overlying landowners sufficient time to react to such

a declaration. In the Agreement, the District serves as the technical advisor to both the Landowners and Municipal Users.

The Agreement recognizes the need for monitoring and appropriate management of the existing Basin supplies and also recognizes that bringing additional water resources to the Basin could delay or avoid entirely the Basin becoming overdrafted in the future. The Agreement also recognizes signatories' desire to preserve their respective groundwater rights, notwithstanding implementation of any management measures, thereby providing the framework for cooperation among the Landowners and Municipal Users to participate in the development of a groundwater management plan.

1.3.6 San Luis Obispo County Region Integrated Regional Water Management Plan (2007)

The District, in cooperation with the District's Water Resources Advisory Committee (WRAC), prepared the Region's Integrated Regional Water Management Plan (IRWMP) to align water resources management planning efforts for achieving sustainable water resources Countywide with the State planning efforts through 2030. The IRWMP was used to support the Region's water resource management planning and submittal of grant applications to fund these efforts. The IRWMP established specific goals and objectives to achieve water resources sustainability. The IRWMP integrated 19 different water management strategies that have or will have a role in protecting the region's water supply reliability, water quality, ecosystems, groundwater, and flood management objectives. The integration of these strategies resulted in a list of action items (projects, programs, and studies) needed to implement the IRWMP. District staff and the WRAC Integrated Regional Water Management Subcommittee prioritized the action items. The IRWMP was adopted in December 2005 and updated in July 2007.

The IRWMP identified the following groundwater monitoring and management objectives that are intended to ensure the region's groundwater resources remain suitable for continued use.

- Continue monitoring and reporting programs for groundwater basins in the region.
- Evaluate and consider groundwater banking programs.
- Protect and improve groundwater quality from point and non-point sources of pollution.
- Conduct public education and outreach regarding groundwater protection.
- Identify areas of known or expected conflicts and target stakeholders on specific actions that they should take to help protect groundwater basin quality and supply.
- Recharge groundwater with high-quality water.

The groundwater management objectives and strategies presented for the Region in the IRWMP will be used to guide the development of the Groundwater Management Plan for the Basin.

1.3.7 City of Paso Robles Urban Water Management Plan (2007)

The Urban Water Management Plan (UWMP) supported the IRWMP by describing the City's current and future water demands, identifying current water supply sources, and assessing supply reliability for the City. The UWMP describes the City's reliance on groundwater and its support of efforts to avoid overdraft by developing additional sources. These sources include water conservation, surface water from Lake Nacimiento, and the use of recycled water for irrigation. The Plan identifies beneficial impacts to groundwater quality through the use of these sources.

1.3.8 Water Resources Plan Integration and Capital Improvement Program (2007)

The City prepared the integrated plan at the conclusion of eight significant water resource reports prepared on the City's behalf. The integrated plan is a sequencing of the recommended actions from the eight individual plans, accompanied by a capital improvement program to provide funding. This document captures the City's overall water resource goals and identifies a self-sustaining water resource portfolio for the City, along with steps necessary to build that portfolio. The Plan reinforced the need for the City to secure entitlement of water from the Nacimiento Water Project. The City's decade long involvement in the Nacimiento Water Project culminated in 2004 when the City secured the entitlement to 4,000 acre-feet per year from the Nacimiento Water Project. Since then, the City has embarked on design of a water treatment plant in 2007, developed a private well policy in 2007, and is poised to upgrade the City's wastewater treatment plant to facilitate water recycling efforts.

1.3.9 Annual Report on the Paso Robles Groundwater Basin (2007)

The Annual Report on the Paso Robles Groundwater Basin (Annual Report) was prepared in 2007 to continue to monitor and evaluate groundwater conditions in order to delay or avoid Basin overdraft. The Annual Report provides an update of the rainfall, groundwater levels and storage, and groundwater management planning for the 1997 to 2006 period that has taken place since the completion of the Basin Study (Phase I Report) in 2002, which included the 1981 to 1997 period.

During the 1997 to 2006 period, this report estimated that groundwater storage declined by about 29,800 acre-feet (about 3,300 acre-feet per year). Recommendations from the Annual Report include continuing the cooperative efforts to improve groundwater level monitoring and updating the groundwater pumping estimates from the Phase I report.

1.3.10 Paso Robles Groundwater Basin Water Banking Feasibility Study (2007)

The Paso Robles Groundwater Basin Water Banking Feasibility Study (Feasibility Study) was identified as an "A1" priority project in the County's IRWMP and was undertaken by the District to determine the feasibility of banking available State Water Project (SWP) supplies in order to improve the overall water supply reliability in the County. This investigation is important to the region because it evaluates opportunities to more fully utilize the unused portion of the District's 25,000 acre-feet per year SWP supply, which could

improve local groundwater conditions, increase dry-year water supplies, improve local groundwater quality, provide greater flexibility in groundwater management, and reduce the dependence on imported water supplies in below normal years.

The primary purpose of the Feasibility Study was to determine the technical feasibility of a recharge or water banking project in the Basin. The technical feasibility was based on the local hydrogeologic suitability and engineering feasibility. Additional groundwater management and operational considerations as well as environmental and permitting issues were also identified. Three potential recharge areas were evaluated separately for both recharge and water banking alternatives. Two of the areas may provide opportunities for recharge or water banking operations. The Feasibility Study was only based on physical feasibility and design. Institutional and cost considerations would need to also be addressed to determine if the project should be implemented in those locations.

Some of the groundwater management related recommendations from this project included:

1. Preparing a groundwater management plan to provide a framework for managing the Basin and establishing Basin Management Objectives.
2. Continue the District's annual groundwater monitoring plan to track changes in groundwater levels and quality.
3. Installing dedicated monitoring wells, as needed, to fill data gaps.

1.3.11 Evaluation of Paso Robles Groundwater Basin Pumping – Water Year 2006 (2009)

This report updates the pumping estimate from the Paso Robles Groundwater Basin Study (Basin Study), which provided estimates of pumping for water years 1997 and 2000.

This report utilized land use, population, well production, well locations, and water demand information to estimate the 2006 groundwater pumping by use sector including agricultural, urban, small water systems, and rural groundwater use for the different subareas within the Basin. The estimated groundwater pumping in 2006 totaled 88,154 acre-feet, about 90 percent of the estimated perennial yield (97,700 acre-feet) for the entire Basin. Pumping within the Atascadero Subbasin in 2006 totaled 15,532 acre-feet, about 94 percent of the estimated perennial yield (16,400 acre-feet).

A new estimate of projected groundwater pumping in 2025 was made based upon this information. The annual groundwater pumping projected for 2025 totaled 107,779 acre-feet (adjusted for gross agricultural pumping), about 110 percent of the perennial yield.

1.3.12 Paso Robles Groundwater Basin Water Balance Review and Update (2010)

This report provides an update of the water balance for the Paso Robles Groundwater Basin and the Atascadero Subbasin for the water years 1998 to 2009, as well as an analysis of the effect of importing water on the water balance for both the Basin and Subbasin for the future period of 2010 to 2025.

The water balance calculations presented in the report show that demand in both the Atascadero Subbasin and the Paso Robles Groundwater Basin as a whole is approaching the average annual perennial yield. The results of this study suggest that future groundwater storage investigations should evaluate the groundwater storage separately for the three different aquifer regimes (shallow alluvial aquifers, the Paso Robles Formation in the Subbasin, and the Paso Robles Formation within the entire Basin). This study reinforces the need for the implementation of an effective monitoring plan to further improve the understanding of the relationships between the aquifer regimes and support improved groundwater management in the Basin.

1.3.13 San Luis Obispo County Master Water Plan (2010, ongoing)

The purpose of the County Master Water Plan is to present a complete picture of the water resources management in San Luis Obispo County and how the practices (i.e., water use, policy adoption, planning, and project implementation) of all the entities within the County influence each other with respect to water resources. This ongoing project separates the County into three sub-regions (North Coast, South Coast, and Inland) and further divides them into sub-regional Water Planning Areas (WPAs) that were formed in consideration of physical boundaries such as groundwater basins and watershed and jurisdictional boundaries. Information is summarized in the Master Water Plan for the WPAs.

Technical Memorandum No. 3 titled 'Task C.3 Water Supply Inventory and Assessment-Water Supply, Demand, and Water Quality provides a draft summary of the existing and projected water demands and supplies within the County for local purveyors. The Paso Robles Groundwater Basin is included within WPA 13 and 14 within the Inland Sub-Region.

1.3.14 Peer Review of Paso Robles Groundwater Basin Studies

An independent review of the groundwater basin studies was prepared to compare some approaches and conclusions of previous reports regarding the status of the conditions in the Paso Robles Groundwater Basin. A total of five reports were reviewed as part of the peer review, which included a more detailed comparison of the Todd 2009 Report and the Fugro 2010 Report. The Todd report found declines in the basin and subbasin storage between the 2000 and 2006. The peer review concluded that groundwater pumping was nearing the perennial yield, and those efforts to supplement the groundwater supplies will help to maintain the balance. The peer review recommended several courses of action that included:

- Continuing to monitor groundwater levels across the Basin and improve monitoring in areas not currently covered in the County's water level monitoring program.
- Update and enhance the groundwater flow model.
- Secure supplemental water supplies to reduce groundwater pumping.
- Support cooperative groundwater management in the Basin.

1.3.15 Revised Resource Capacity Study – Water Supply in the Paso Robles Groundwater Basin

The Resource Capacity Study (RCS) addresses the state of the Paso Robles Groundwater Basin based on work already completed, which included:

- Paso Robles Groundwater Basin Study (Fugro, 2002)
- Paso Robles Groundwater Basin Study Phase II – Numerical Model Development, Calibration, and Application (Fugro, 2005)
- Evaluation of Paso Robles Groundwater Basin Pumping – Water Year 2006 (Todd, 2009)
- Paso Robles Groundwater Basin Water Balance Review and Update (Fugro, 2010)

These studies have calculated the water use by major water use sectors (agriculture, rural land uses, small commercial uses, municipal systems, and small community systems). The results of these studies show that groundwater use has increased during the 1980 to 2009 period to the point where the Basin outflows (including groundwater pumping) will soon be greater that Basin inflows (recharge).

The County's Resource Management System (RMS) provides a mechanism for ensuring a balance between land development and the resources necessary to sustain such development. When a resource deficiency becomes apparent, efforts are made to determine how the resource capacity might be expanded, where conservation measures could be introduced to extend the availability of the unused capacity, or where development should be limited or redirected to areas with remaining resource capacity.

The RMS uses three levels of severity designations from Level of Severity I (least severe) to Level of Severity III (most severe) based on the rate of depletion and an estimate of the remaining capacity, if any. The Levels of Severity for water supply are summarized below:

1. **LOS I:** Level I is reached for a water resource when increasing water demand projected over nine years equals or exceeds the estimated dependable supply.

2. **LOS II:** Level II for a water resource occurs when water demand projected over seven years (or other lead time determined by a resource capacity study) equals or exceeds the estimated dependable supply.

3. **LOS III:** A Level of Severity III exists when water demand equals the available resource; the amount of consumption has reached the dependable supply of the resource.

According to the above designation, an LOS III can be established if a basin has reached its perennial yield *or dependable supply will be depleted before new supplies are developed* (emphasis added in RCS). The January RCS recommends a Level of Severity III for the Paso Robles Groundwater Basin and a level of Severity I for the Atascadero Basin.

The RCS also recommended actions to include:

- Water conservation measures that will lead to more efficient water use.
- Land use controls that will reduce conflicts over the limited groundwater resource.

The RCS also recognizes the following important decision-making constraints, which complicate any action the County may wish to take:

- The County has a limited regulatory role in water use, especially by cities and agriculture. Therefore it will be difficult for the County to directly affect the use of water by the two primary groundwater users.
- The County's primary regulatory role is land use regulation and building permit issuance.
- The major portion of the basin outflows are not measured, but are estimated. While municipal pumping is measured, agricultural, rural, and small community/commercial pumping is estimated. This adds uncertainty regarding actual groundwater use.
- Identification of changing groundwater levels is based on somewhat limited data.

Because the County's primary regulatory role is land use regulation and issuance of building permits, it had developed recommended actions that emphasize this regulatory role. These actions are consistent with the County's General Plan in the Conservation and Open Space Element and the Agricultural Element.

2 Need for Groundwater Management Planning

2.1 Legislative Requirements

Groundwater management is planned and coordinated locally to ensure a sustainable groundwater basin to meet future water supply needs. With the passage of AB 3030 in 1992, local water agencies were provided a systematic way of formulating Groundwater Management Plans (GMPs) (California Water Code, Sections 10750 et seq.). AB 3030 also encourages coordination between local entities through joint power authorities or Memorandums of Understanding (MOU).

AB 3030 was amended in 2002 with the passage of The Groundwater Management and Planning Act of 2002 (SB 1938). The act amends existing law related to groundwater management by local agencies. The law requires any public agency seeking State funds administered through DWR for the construction of any groundwater projects or groundwater quality projects to prepare and implement a GMP with certain specified components. Prior to this legislation, there were no required plan components. New requirements include establishing Basin Management Objectives, preparing a plan to involve other local agencies in a cooperative planning effort, and adopting monitoring protocols that promote efficient and effective groundwater management.

2.2 GMP Components

The Paso Robles Groundwater Management Plan includes three types of components: SB 1938 mandatory components, AB 3030 and SB 1938 voluntary components, and DWR Bulletin 118-suggested components. The seven mandatory components that are required to be compliant with SB 1938 are addressed in the GMP. The GMP also addresses the 12 specific technical elements identified in the California Water Code, along with the seven recommended components identified in DWR Bulletin 118 (DWR 2003). Table 2-1 lists the required and recommended components and identifies the specific location within this GMP where the information can be found.

Table 2-1. Paso Robles Basin GMP Components

Components	Section
SB 1938 Mandatory Components	
1. Documentation of public involvement statement	Appendix C
2. Basin Management Objectives (BMOs)	Section 4
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping	Section 4 and Appendix D
4. Plan to involve other agencies located in the groundwater basin	Section 6
5. Adoption of monitoring protocols	Appendix E
6. Map of groundwater basin boundary, as delineated by DWR Bulletin 118, with agency boundaries that are subject to GMP	Section 3
7. For agencies not overlying groundwater basins, prepare the GMP using appropriate geologic and hydrogeologic principles	Not Applicable
AB 3030 and SB 1938 Voluntary Components	
1. Control of saline water intrusion	Section 5
2. Identify and manage well protection and recharge areas	Section 5
3. Regulate the migration of contaminated groundwater	Section 5
4. Administer well abandonment and destruction program	Section 5
5. Control and mitigate groundwater overdraft	Section 5
6. Replenish groundwater	Section 5
7. Monitor groundwater levels	Section 4 and Appendix E
8. Develop and operate conjunctive use projects	Section 7
9. Identify well-construction policies	Section 5
10. Develop and operate groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects	Section 5
11. Develop relationships with State and federal regulatory agencies	Section 6
12. Review land use plans and coordinate with land use planning agencies to assess activities that create reasonable risk of groundwater contamination	Section 5 and Section 7
DWR Bulletin 118 Suggested Components	
1. Manage with guidance of advisory committee	Section 6
2. Describe area to be managed under GMP	Section 1
3. Create links between BMOs and goals and actions of GMP	Section 4
4. Describe GMP monitoring programs	Section 4 and Appendix E
5. Describe integrated water management planning efforts	Section 7
6. Report of implementation of GMP	Section 7
7. Evaluate GMP periodically	Section 7

2.3 Purpose and Goals of the Groundwater Management Plan

This document presents a locally developed, stakeholder-driven GMP that reflects current State law; coordinates existing groundwater management; and defines actions for developing projects and management programs to monitor the operation of the groundwater basin and to improve the long-term sustainability of groundwater resources in the Paso Robles Groundwater Basin.

This GMP provides action items that, when implemented, will maintain or enhance groundwater levels and water quality, minimize inelastic land subsidence, and manage available surface and groundwater conjunctively to allow greater operational flexibility.

The purpose of the GMP is to provide a framework for coordinating groundwater and surface water management activities into a cohesive set of management objectives and implementing the actions necessary to meet those objectives.

The purposes of this project include:

- Build upon the existing organization of local water purveyors, agricultural interests, and individual stakeholders to develop a regional understanding of the groundwater setting and groundwater management opportunities in the Basin.
- Formulate groundwater management actions that lead to improved groundwater information gathering and data management within the Basin.
- Identify water supply and demand management projects and programs that can be implemented to improve long-term water supply reliability in the Basin.
- Establish a regional and on-going approach to groundwater management that is accepted in the Basin and recognized by other local, State, and federal agencies and that can be used successfully to pursue grant funding to implement projects that support improved groundwater management.

The project goals include:

- Alert stakeholders to the state of the Basin and the actions needed to keep this Basin in balance and avoid heading into the projected state of overdraft.
- Complete and adopt the GMP, particularly the BMOs.
- Expand the existing groundwater monitoring program, consider additional monitoring efforts, and develop an annual reporting format for the Basin Plan area.
- Continue to coordinate recent land and water use analysis for the Basin with countywide planning efforts such as the Resource Capacity Study and implementation of the Conservation Element of the General Plan, which is led by the Planning Department, and County Master Water Plan, which is led by the Public Works Department.

Key results of the planning process documented in this GMP include:

- Developing general consensus among stakeholders regarding the characterization of the area's water problems, current and future demands, and groundwater conditions.
- Documenting the area's groundwater management goals and objectives, including specific BMOs, to help measure progress in attaining goals.
- Developing specific groundwater management actions and common programs for the Paso Robles Groundwater Basin.
- Developing management plan components to maintain groundwater quality and prevent land subsidence in the basin.
- Providing an implementation plan to direct future groundwater management activities.

2.4 Authority to Prepare Regional Groundwater Management Plan

The San Luis Obispo County Flood Control and Water Conservation District has the authority to prepare a groundwater management plan within the unincorporated portions of the Paso Robles Groundwater Basin within San Luis Obispo County through California Water Code, Division 6, Part 2.75 (Sections 10750 et seq.). The City of Paso Robles has the authority to manage the groundwater resources within their city limits. The City of Paso Robles and the District acted as co-project managers in development of this GMP. This GMP is consistent with the provisions of California Water Code, Sections 10750 et seq., as amended January 1, 2003.

3 Water Resources Setting

This section summarizes the water resources conditions present in the GMP area. It describes the historical and baseline conditions of the water resources in the Paso Robles Basin and contains an overview of the physical setting, including the climate, soils, and geology and describes the major planning considerations related to those issues. This section includes a discussion of the current and future land use and associated water demands, water supplies and sources, existing water supply facilities, groundwater levels, and water quality conditions.

3.1 Scope and Approach

Previous reports were reviewed and the available data were analyzed to document the historical and existing conditions of the groundwater basin and to identify unique characteristics of the GMP area. Groundwater data were analyzed to evaluate trends, document changes in storage, and assess groundwater occurrence, flow, and quality. Groundwater hydrographs were prepared at different locations throughout the GMP area. The results of the analyses were used by the Groundwater Advisory Committee (GAC) stakeholders to establish GMP goals and objectives. The data and results of the analyses are summarized in this section. More detailed data and results are provided in the appendices.

3.2 Physical Setting

3.2.1 Groundwater Basin

The Basin was first formally defined by the California Department of Water Resources (DWR, 1958). In 1979, the DWR published a detailed investigation of the San Luis Obispo County portion of the Basin (DWR, 1979).

The Basin encompasses an area of approximately 505,000 acres (790 square miles). The Basin ranges from the Garden Farms area south of Atascadero to San Ardo in Monterey County, and from the Highway 101 corridor east to Shandon (Figure 1-1). Most of the Basin is hydraulically connected by thick sedimentary sections. The Basin is divided into smaller subareas based on water quality, source of recharge, groundwater movement, and the contours of the base of permeable sediments.

The Atascadero Subbasin is a hydrologically distinct subbasin within the Basin, and encompasses the Salinas River corridor area south of Paso Robles and includes the communities of Garden Farms, Atascadero, and Templeton. The Atascadero Subbasin is defined as that portion of the Basin west of the Rinconada fault. Between Atascadero and Creston, the Rinconada fault juxtaposes less permeable Monterey Formation rocks with the Paso Robles Formation basin sediments. South of the City of Paso Robles, the Paso Robles Formation is found on both sides of the Rinconada fault; however, the fault zone is believed to form a leaky barrier that restricts flow from the Atascadero Subbasin to the main part of

the Basin in the Paso Robles Formation. The alluvial deposits along the Salinas River overlie the Paso Robles Formation and are not affected by the fault, so groundwater flow in the alluvium between the Atascadero Subbasin and the rest of the Basin is not impeded.

The western boundary of the Basin roughly follows Highway 101 from Santa Margarita northward to Hames Valley. The eastern boundary follows a rough line from Highway 58 in the San Juan Creek area northward to Shandon and Cholame. The Basin is downstream of and hydraulically connected by alluvial deposits to the Pozo Groundwater Basin south of the Basin, and to the Cholame Groundwater Basin north of the Basin. The Basin outlet is northwest of and downstream of Bradley, where it is hydraulically connected with the Salinas Valley Groundwater Basin.

These adjacent basins do not provide significant recharge to the Paso Robles Groundwater Basin. Recharge to the Basin occurs by percolation of stream water and by infiltration of precipitation. No distinct areas of recharge have been identified (i.e. forebay), so it is assumed to be distributed throughout the Basin.

The Basin was subdivided into subareas in the Phase I Report as a practical approach to organize the 790 square mile Basin into smaller informal areas (see Figure 1-1) and listed below:

1. Atascadero Subbasin
2. Creston Subarea
3. San Juan Subarea
4. Estrella Subarea
5. Shandon Subarea
6. North Gabilan Subarea
7. South Gabilan Subarea
8. Bradley Subarea

These subareas are not hydrologically distinct. Groundwater and surface water flows occur between subareas. However, dividing the Basin into subareas enables Basin Management Objectives and Groundwater Management Activities (GMAs) to be tailored to the water use characteristics of the subareas.

3.2.2 Basin Topography

The Paso Robles Groundwater Basin is a broad, flat valley with the Estrella River running westward into the Salinas River. The Salinas River runs along the western side of the valley northward toward Monterey County and out of the basin. Surrounding the basin are rolling hills and mountains. To the north and northeast are the Gabilan Highlands and Cholame Hills, and to the west and south are the Santa Lucia and La Penza Ranges. Numerous drainages flow from these hills into the Estrella and Salinas Rivers.

3.2.3 Geology

The stratigraphy in the watershed of the Basin includes the water-bearing geologic units that form the Basin aquifer, and the non-water bearing geologic units that underlie and are adjacent to the Basin sediments. Brief descriptions of the water bearing and non-water bearing geologic formations are provided below. The complete description of the geology and hydrogeologic setting is provided in the Paso Robles Groundwater Basin Study (Fugro, 2002).

3.2.3.1 Alluvium

Alluvial deposits occur beneath the flood plains of the rivers and streams within the basin. These deposits reach a depth of about 100 feet below ground surface and are typically comprised of coarse sand and gravel.

3.2.3.2 Paso Robles Formation

The Paso Robles Formation extends from ground surface and is typically 700 to 1,200 feet thick, although thicknesses of more than 2,500 feet occur in some areas. The formation is a Plio-Pleistocene, predominantly non-marine geologic unit comprised of relatively thin, often discontinuous sand and gravel layers interbedded with thicker layers of silt and clay. It was deposited in alluvial fan, flood plain, and lake depositional environments. The formation is typically unconsolidated and generally poorly sorted.

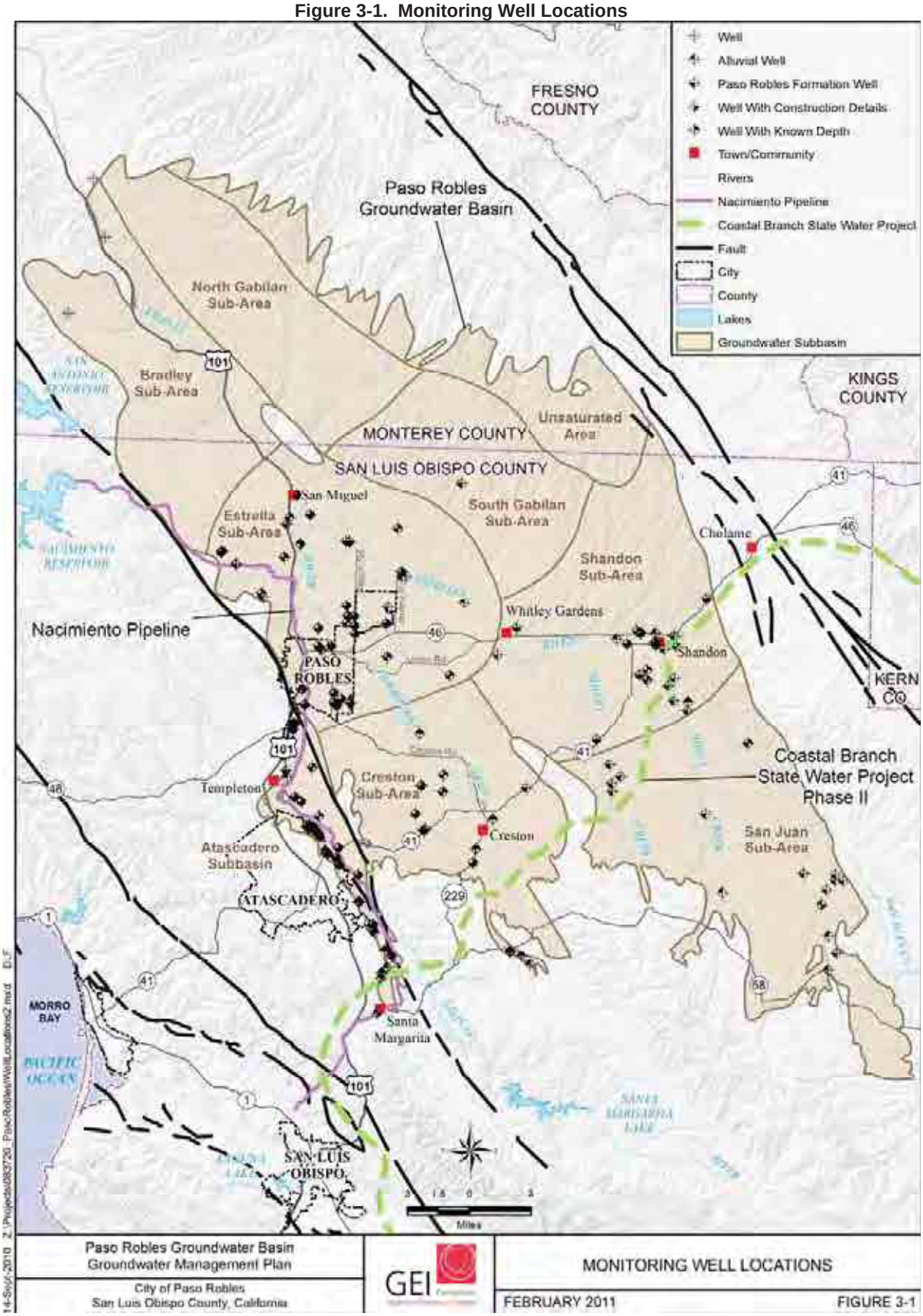
3.2.3.3 Older Formations

Underlying the basin sedimentary beds are older geologic formations that typically have lower permeability and/or porosity. In some cases, these older beds yield in excess of 50 gpm but they often have poor quality water or are of limited extent, such as are found along a fault fracture zone. The older geologic units crop out along the basin border. In general, the geologic units underlying the basin include Tertiary-age consolidated sedimentary beds, Cretaceous-age metamorphic rocks, and granitic rock.

3.3 Groundwater Conditions

In the Basin, the County has been monitoring groundwater levels for more than 40 years. In 2003, an evaluation of the monitoring network was completed to evaluate the efficiency and effectiveness of the County's Monitoring Program for wells located in the Basin. Based on the final report, approximately 159 wells in the monitoring program (see Figure 3-1). Most wells are monitored by County Public Works employees and remaining wells are monitored by local municipal water company employees (who forward the data to the County's Public Works Department for inclusion in the monitoring program database). Additionally, three wells are located in Monterey County and are monitored by the Monterey County Water Resources Agency.

Figure 3-1. Monitoring Well Locations



San Luis Obispo County's existing groundwater level monitoring network in the Basin was used as the initial data set to identify potential wells that are representative of groundwater conditions in different areas of the Basin. This initial set of wells was screened to identify a short list of representative wells for each subarea. Table 3-1 identifies the number wells currently included in the monitoring network.

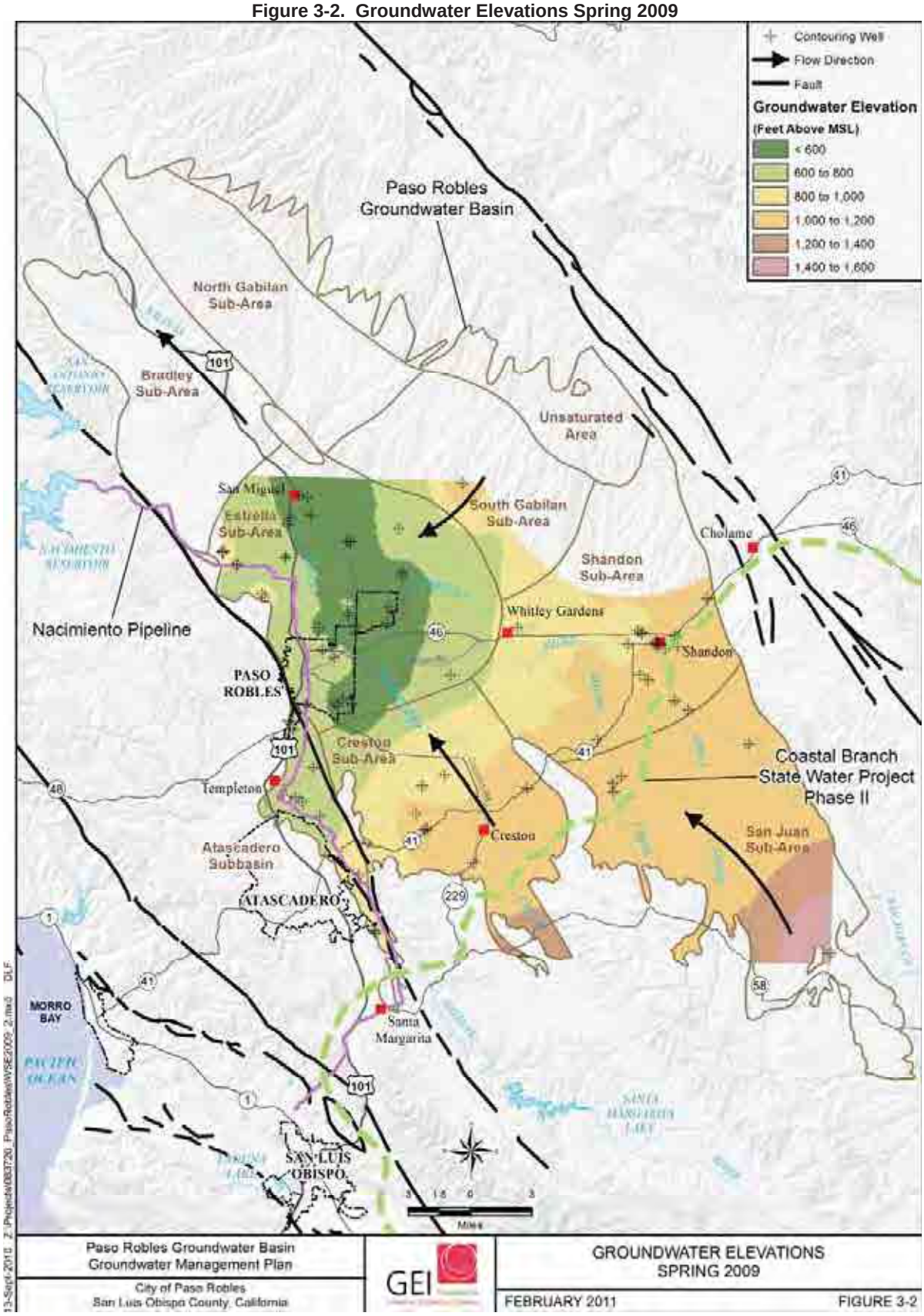
Table 3-1. Wells in the San Luis Obispo County Monitoring Network

Groundwater Subarea	Wells Currently in Program
Atascadero Subbasin	51
Bradley	0
Creston	17
Estrella	50
Gabilan (North and South)	1
San Juan	16
Shandon	24
TOTAL	**159**

3.3.1 Current Groundwater Levels

The most recent groundwater level elevation map is from the spring of 2009 shows that groundwater levels in the Basin range from approximately 1,500 feet above mean sea level (msl) in upland areas to less than 600 feet msl in the northwestern Bradley area as shown on Figure 3-2. Groundwater moves generally northwesterly from the San Juan area into Shandon and then into the Estrella area. Groundwater flow from Creston is also northerly into the Estrella area. In the northern portion of the Basin, groundwater moves southwesterly toward Estrella and the Salinas River in the area near San Miguel.

Figure 3-2. Groundwater Elevations Spring 2009



3.3.2 Change in Groundwater Levels

A groundwater elevation change map has been prepared that represents the changes in groundwater levels for the 1997 to 2009 period and is shown on Figure 3-3. This map shows that the greatest change in groundwater elevations has occurred in the Estrella Subarea, and to a lesser extent in the Creston and Shandon Subareas. Groundwater levels in the western portion of the Paso Robles Basin have declined in excess of 70 feet since 1997 during a period when precipitation was just slightly less than the to the long-term average annual precipitation.

The area with the greatest change in groundwater elevation has been identified in the Resource Capacity Study as the Estrella/Creston Area of Concern, and has been shown to have the greatest and most consistent decline of water levels since 1980. While there is no perennial yield estimate for this area, the sustained groundwater level decline represents a stressing of the groundwater resource and has resulted in water quality problems or has required wells to be deepened.

Additional information on the changes in groundwater levels for each of the subareas is provided in Section 4.4.The continuing decline suggests that, at least locally, the rate of extraction exceeds the ability of the basin to recharge the area.

3.3.3 Soil Characteristics and Surface Recharge Potential

Most of the groundwater recharge in the Paso Robles Basin results from the infiltration of precipitation. Surface recharge potential in the Paso Robles Basin is a function of soil type. As such, the surface soil conditions are one of the primary factors affecting groundwater recharge in the Paso Robles Basin.

The surface recharge potential of the soil was interpreted based on the hydrologic soil groups as categorized by the Natural Resources Conservation Service (NRCS). Hydrologic soil groups are classified according to their ability to infiltrate water and affect runoff. The soils are grouped according to the amount of water infiltration when the soils are thoroughly wet and receive additional precipitation. The four hydrologic soil groups are:

Group A: Soils having a high infiltration rate (low runoff potential) when thoroughly wet.
Group B: Soils having a moderate infiltration rate when thoroughly wet.
Group C: Soils having a slow infiltration rate when thoroughly wet.
Group D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet.

Figure 3-4 shows the hydrologic soil groups in the Paso Robles Basin. The areas associated with soils with highest infiltration rate (Group A) are located along small stretches of the larger rivers and creeks in the basin, including the Salinas River, Estrella River, and Huerhuero Creek. In general, Group B soils (i.e., those with moderate infiltration rate) are located predominately on the valley areas of the Paso Robles Basin in the Atascadero Subbasin, San Juan Subarea, and portions of the Creston and Estrella Subareas. Group C and Group D soils are present on the hills surround the basin floor.

Figure 3-3. Difference in Spring Groundwater Elevations 1997 to 2009

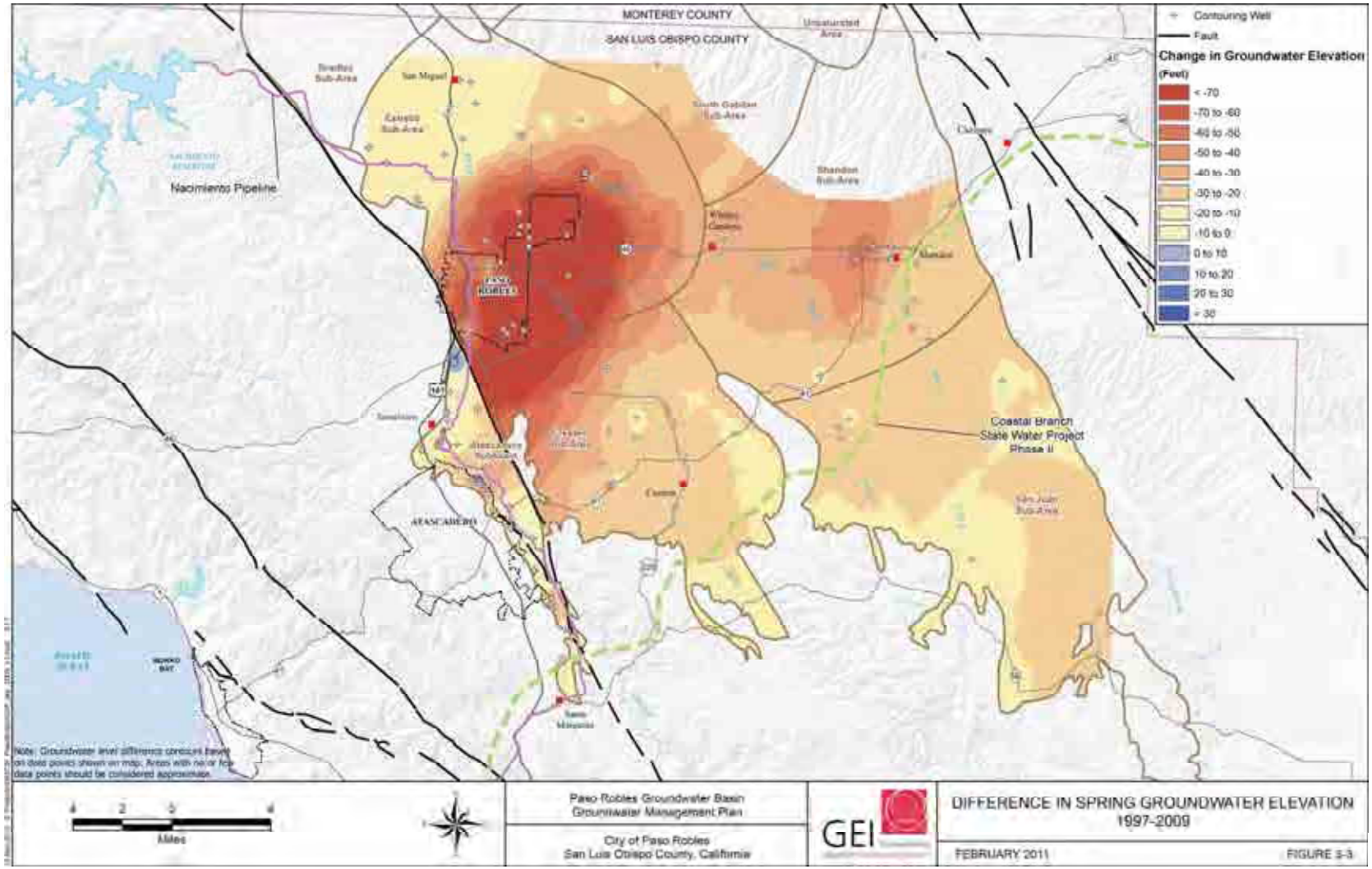
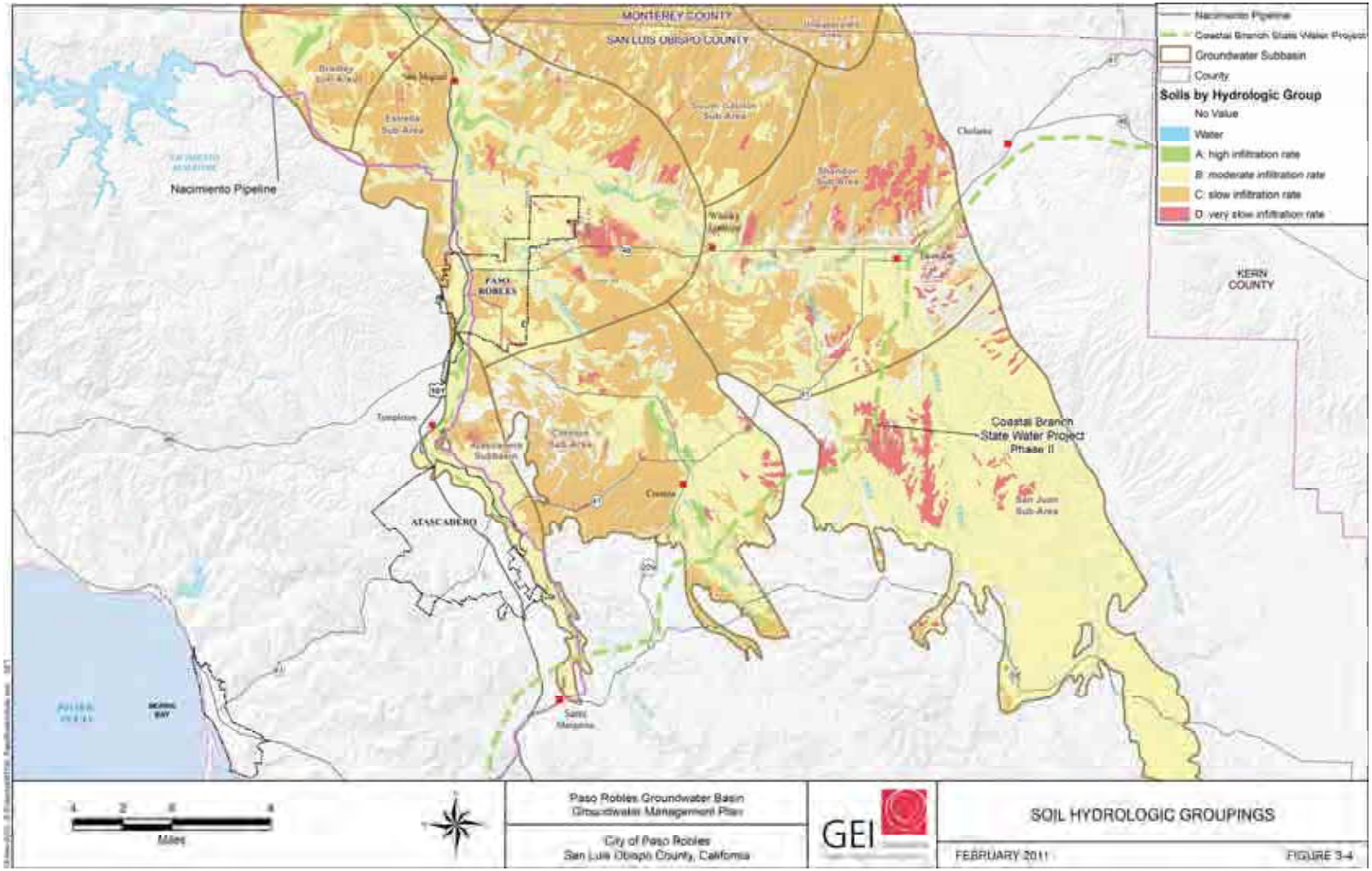


Figure 3-4. Soil Infiltration Rates



3.4 Land Subsidence Conditions

Land subsidence is the lowering of the land surface elevation due to changes that occur underground. Common causes of land subsidence from human activities include pumping water, oil, and gas from subsurface reservoirs; dissolution of limestone, causing sinkholes; collapse of underground mines; drainage of organic soils; and hydro-compaction. Historically, there has been land subsidence in California resulting from over drafting of the groundwater basin.

No direct measurements of subsidence have been made in the area using extensiometers or repeat benchmark calibration. However, InSAR has been used in the area to remotely map land-surface displacements. This technology uses radar images taken from satellites that are used to create maps of change in land surface elevation. The studies done in the area show that an area three miles northeast of Paso Robles has shown a downward displacement from 0.6 to 2.1 inches (Valentine, D. W. et al., 1997). There is no direct correlation of the measured land subsidence with change in groundwater levels over a long period in time, but some of the areas of land subsidence appear to correspond with areas of significant groundwater level decline between the spring of 1997 and fall of 1997.

3.5 Groundwater Quality Conditions

The Phase I Report (Fugro and Cleath, 2002) describes the general water quality of the groundwater Basin with respect to general minerals and selected minor constituents. The Phase I Report analysis indicated generally good overall water quality, but noted some areas of rising concentrations of total dissolved solids (TDS), chloride, and nitrate. Potential sources of these three constituents could include wastewater discharges, agricultural practices, irrigation with recycled water, and/or pumping or upwelling from deeper aquifers.

In general, the quality of groundwater in the Basin is relatively good, with few areas of poor quality and few significant trends of ongoing water quality deterioration. Historical water quality trends were evaluated to identify areas of deteriorating water quality. A major water quality trend is defined as a clear trend that would result in a change in the potential use of water within 50 years, if continued. The following major trends of water quality deterioration in the Basin were identified:

- Increasing TDS and chlorides in shallow Paso Robles Formation deposits along the Salinas River in the central Atascadero Subbasin.
- Increasing chlorides in the deep, historically artesian aquifer northeast of Creston.
- Increasing TDS and chlorides near San Miguel.
- Increasing nitrates in the Paso Robles Formation in the area north of Highway 46, between the Salinas River and the Huerhuero Creek.
- Increasing nitrates in the Paso Robles Formation in the area south of San Miguel.
- Increasing TDS and chlorides in deeper aquifers near the confluence of the Salinas and Nacimiento rivers.
- Increasing levels of arsenic and manganese in the City of Paso Robles wells.

These trends underscore the need for improved management of the Basin to mitigate declining groundwater levels in several areas of the Basin.

3.6 Climate-Precipitation

The Paso Robles Groundwater Basin has a semi-arid Mediterranean climate, which is characterized by hot sunny summers and cool winters. Most of the precipitation occurs in the winter between November and April.

Rainfall is the primary source of recharge to the groundwater basin, and it is pertinent to understand rainfall's relationship to groundwater management activities in the basin. The average rainfall over the basin ranges from about 18 inches in the west (at the Atascadero MWC Gage #34) to 11 inches in the east (at the Shandon #73) as shown on Table 3-2. Figure 3-5 shows the location of selected precipitation stations in the basin. The historical annual rainfall recorded is represented along the Salinas River at Paso Robles Gage (Gage #10) for the 1960 to 2009 period (50 years), shown on Figure 3-6. During this period, rainfall was highly variable, ranging from about 5 inches to over 30 inches per year, and averaging 14.88 inches per year.

Table 3-2. Precipitation Stations in the Paso Robles Groundwater Basin

Precipitation Station	Period of Record	Average Annual Precipitation (inches)			
		Period of Record	1960 to 2009	1981 to 2009	1997 to 2009
Paso Robles Gage #10	1901 to 2009	15.04	14.88	14.49	13.73
Atascadero Mutual WC #34	1931 to 2009	17.65	17.85	17.58	17.49
Erickson Ranch 52.1	1928 to 2009	11.89	12.81	12.85	13.15
Shandon # 73	1937 to 2009	10.69	10.76	11.10	11.06
Sinclair #125	1949 to 2009	11.69	12.02	12.21	11.67

Figure 3-5. Precipitation and Surface Water Gaging Stations in the Paso Robles Area

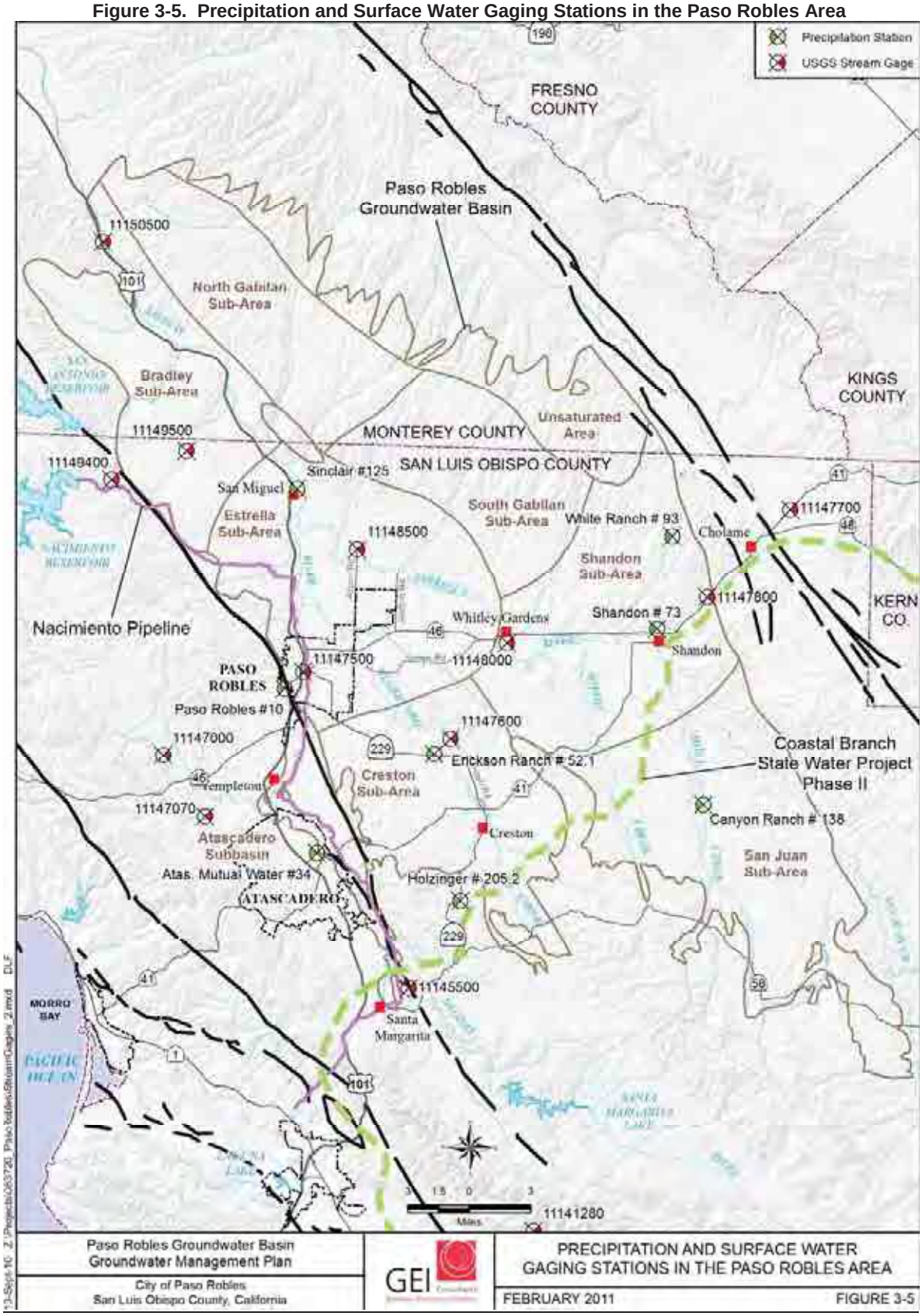
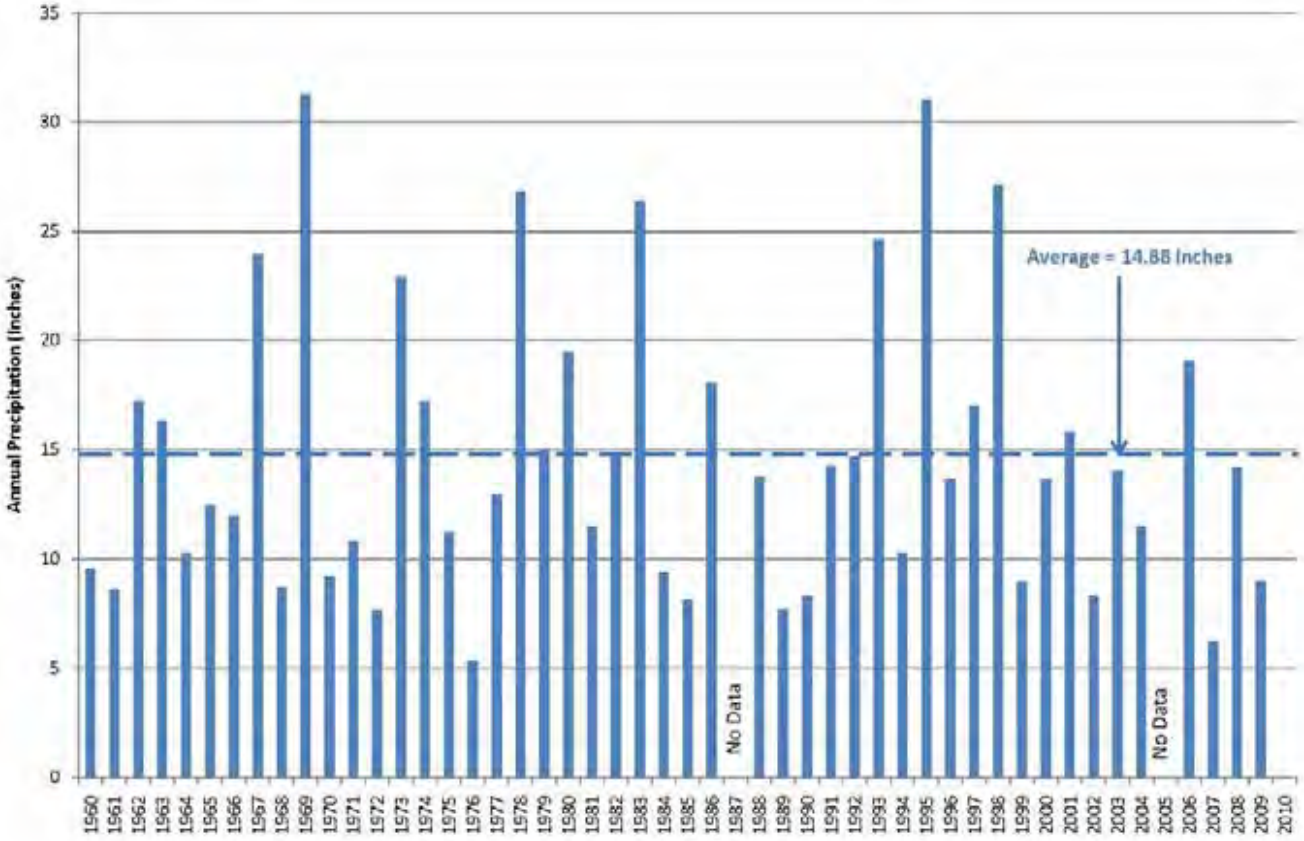


Figure 3-6. Annual Precipitation at the Paso Robles Gage for 1960-2009



For the last 13 years (1997 to 2009) the rainfall at this gage has averaged 14.6 inches per year as shown on Figure 3-6 and included both dry and wet periods typical of the long-term record. This period (2000-2009) is fairly representative of the overall rainfall annual amounts and variation.

3.7 Water Supplies

Historically, California water users have relied on multiple sources of water supply in order to meet changing and increasing water demands. Typically, local water providers mix and match their supply sources to maximize water supply and quality and minimize costs to meet both current and long-term water supply requirements. Water users in the Paso Robles Groundwater Basin have relied almost exclusively on groundwater. Beginning in 2010 surface water will become available to some purveyors on the west side of the basin to reduce the local groundwater pumping demand. This section briefly describes the groundwater and surface water supplies available in the Basin.

3.7.1 Surface Water Supplies

Two water supplies available to the Basin include the State Water Project and the Nacimiento Water Project.

3.7.1.1 State Water Project

The California Department of Water Resources operates the State Water Project (SWP). It is the largest State-built water and power project in the United States. Though the SWP first started delivering water in the 1960s, the Central Coast was not served until 1997 when the Coastal Branch Aqueduct, supplying Santa Barbara and San Luis Obispo counties, was completed.

The SWP was built with a capacity to deliver about 4.2 million acre-feet (maf) of water. Recent annual deliveries to the 29 contractors have averaged about 2.3 maf and peaked at 3.5 maf in 2000, so the SWP has available physical capacity to make additional deliveries, assuming the water supply is also available at the same time.

An individual contractor's portion of its SWP annual allocation is presented on Table A of their contract. Table A contract amounts are not a guarantee of the available supply to the contractor each year, but rather a tool in an allocation process that defines an individual contractor's share. The Table A annual allocation for the San Luis Obispo County Flood Control and Water Conservation District totals 25,000 acre-feet at an instantaneous rate of delivery of 35 cfs. This corresponds to a monthly delivery rate of 2,083 acre-feet. The County currently utilizes 4,830 acre-feet per year of the Table A annual allocation, which is delivered to 11 urban water users in the County listed on Table 3-3.

The community of Shandon (through C.S.A No. 16) is the only subscriber to SWP water located in the Basin. They have not accessed this supply. The location for a turnout to the Shandon area was constructed on Coastal Branch. The turnout and additional facilities would need to be completed before SWP water could be delivered to Shandon.

Table 3-3. State Water Project Subscribers Water Users

State Water Project Subscribers Water Users	Amount (AFY)
Avila Beach CSD	100
Avila Valley MWC	20
California Men's Colony	400
C.S.A. No. 16-1	100
County Operations Center	425
City of Morro Bay	1,313
Oceano CSD	750
City of Pismo Beach	1,240
San Luis Coastal USD	7
San Miguelito MWC	275
Cuesta College	200
TOTAL	**4,830**
Drought Buffer	variable
Unassigned Supply	20,170
Total SWP Table A Supply	**25,000**

3.7.1.2 Nacimiento Water Project

The Nacimiento Dam was constructed in 1957 by Monterey County Flood Control and Water Conservation District (now known as the Monterey County Water Resources Agency [MCWRA]). In 1959, San Luis Obispo County secured the rights to 17,500 acre-feet of water per year from Lake Nacimiento. After a long series of studies and negotiations, the Nacimiento Water Project was initiated. Agencies and communities that are participating in the project are listed below and the amount of water they have contracted to receive is shown on Table 3-4. The City of Paso Robles, Atascadero Mutual Water Company, and Templeton Community Services District, which are all part of the Paso Robles Groundwater Basin, currently subscribe to 6,250 acre-feet of water from the Nacimiento Water Project. When these supplies become available, they can be used to offset groundwater pumping and accommodate additional growth.

Table 3-4. Nacimiento Water Project Water Users

NWP Water Users	Amount (AFY)
City of Paso Robles	4,000
Atascadero MWC	2,000
City of San Luis Obispo	3,380
Templeton CSD	250
CSA 10 A	25
Total Assigned	**9,655**
Unassigned Supply	7,845
Total NWP Supply	**17,500**

3.7.2 Groundwater Supplies

The hydrogeologic analysis and later groundwater modeling of the Paso Robles Groundwater Basin estimated the perennial yield for the Basin to be about 97,700 acre-feet per year. The demands on the groundwater basin listed on Table 3-5 show that in 1997, the total annual demand of 76,404 acre-feet per year was about 78 percent of the perennial yield. By 2006, demands had increased to 89,473 acre-feet per year representing about 92 percent of the perennial yield. Projected groundwater demands are estimated to be almost 108,000 acre-feet per year by 2025. This represents 110 percent of the estimated perennial yield.

Table 3-5. Groundwater Pumping Demand in the Paso Robles Groundwater Basin for Selected Years

Demand Type	1997(1)	2006(2)	2025(3)
Agricultural (Estimated Gross Pumping)	51,791	60,000	66,860
Municipal	13,513	15,665	19,373
Small Community Systems(4)			
Small Commercial Systems	1,700	2,323	5,042
Rural	9,400	11,485	16,504
Total Demand	76,404	89,473	107,779
Percent Increase in Demands from 1997			141%
Perennial Yield(5)	97,700	97,700	97,700
Groundwater Demand as Percent of Perennial Yield	78%	92%	110%

Values in Acre-Feet
Notes:
(1)Source: Fugro, 2002 (Table 59)
(2)Source: Todd 2009 (Table 14)
(3)Source: Todd 2009 (Table 14, modified to reflect gross agriculture pumping)
(4)Included in Rural Demands
(5)Source: Fugro, 2005

The water demands and corresponding groundwater pumping is not uniformly distributed across the entire basin. As a result of long-term localized areas of groundwater pumping, groundwater declines are occurring in some parts of the Basin, including the Estrella, Creston, and Shandon Subareas.

3.8 Land Uses and Water Demands within Plan Area

The water demands and supplies for the Paso Robles Groundwater Basin are summarized from several of the documents identified in Section 1. Historically, all water demands in the Basin have been meet with groundwater. This is expected to change in 2010 when Nacimiento Project Water becomes available for use for some of the water users in the Basin.

Water demands in the Basin have generally been organized into five different "user sectors" including:

- **Agricultural** - Agricultural water demands are estimated using the crop acreage and water demands of different types of crops to determine the overall agricultural water demand. This method is used because records of agricultural pumping are not kept and reported.
- **Municipal** - Municipal pumping in the Basin includes four public water purveyors: 1) City of Paso Robles; 2) Atascadero Mutual Water Company; 3) Templeton Community Services District (CSD); and 4) San Miguel Community Services District. Pumping records were used to accurately calculate total municipal pumping.
- **Rural Residential** - Rural pumping includes domestic water use by development in rural areas. The estimate was derived by using parcel data and applying a water use factor, since records are not kept and reported.
- **Small Community Systems** - Small community systems include mutual water companies, county service areas and mobile home parks. For systems that report groundwater pumping, well records were used to accurately determine their pumping. Using these reports, estimates were derived for the systems that do not report their water use.
- **Small Commercial Systems -** Small commercial pumping includes such users as wineries, golf courses, and schools. Water use estimates are based on factors from the Pacific Institute and information from consultation with winery operators.

The demands were distributed to the subareas in the Basin to support the development of subarea-specific Basin Management Objectives as part of the preparation of the Groundwater Management Plan. Table 3-6 shows the distribution of the demands by demand type by subarea for 2006. In 2006, agricultural demands were about 67 percent of the total demand in the Basin, with about one-third of the total agricultural demand occurring in the Estrella Subarea. Municipal demands were about 18 percent of the total demand and are concentrated in the Atascadero Subbasin and the Estrella Subarea. The small community demands are included as part of rural domestic demands. Rural domestic demands were about 13 percent of the total demand. Small commercial demands total about three percent of the total demand, and are concentrated in the Estrella Subarea.

Table 3-6. Distribution of 2006 Water Demands to Subareas

Subarea	Demand Type						
	Agriculture	Municipal	Small Community Systems	Small Commercial Systems	Rural Domestic	Total	Percentage
Atascadero Subbasin	1,348	11,735	0	430	2,032	15,545	17%
Bradley	6,933	0	0	184	109	7,226	8%
Creston	9,936	0	0	37	2,338	12,311	14%
Estrella	23,111	3,930	0	1,603	5,433	34,077	38%
North Gabilan	1,758	0	0	0	50	1,808	2%
San Juan	5,347	0	0	0	105	5,452	6%
Shandon	9,896	0	0	69	1,205	11,170	12%
South Gabilan	1,671	0	0	0	213	1,884	2%
Total	**60,000**	**15,665**	**0**	**2,323**	**11,485**	**89,473**	**100%**
Percent of Total	**67%**	**18%**	**0%**	**3%**	**13%**	**100%**	

The following sections describe the historic water demands for each of the subareas in the Basin.

3.8.1 Atascadero Subbasin

The Atascadero Subbasin is located in the western portion of the Paso Robles Groundwater Basin and has an area of approximately 14,577 acres, which makes up about three percent of the area of the Basin. The Rinconada Fault separates the Atascadero Subbasin from the Paso Robles Basin. The Salinas River flows north roughly paralleling Highway 101 through the subbasin, entering the Estrella Subarea of the Basin near the City of Paso Robles.

This subarea includes the City of Paso Robles and the City of Atascadero's community of Templeton. The Atascadero Mutual Water Company is the water purveyor to the City of Atascadero, but wastewater treatment is provided by the City of Atascadero. The Templeton Community Services District (CSD) provides potable water and wastewater treatment services to the community of Templeton.

Table 3-7 presents the estimated water demands by type for years 1997 and 2006. Municipal demands make up most of the total demand. The total water use in 1997 was estimated at about 14,500 acre-feet and by 2006 totaled about 15,545 acre-feet, representing about 17 percent of the total water use in the Basin. All these demands were met with groundwater, including the Salinas River underflow. Water demands in the Atascadero subbasin increased by about 1,000 acre-feet during the 1997 to 2006 period as shown on Table 3-7.

Table 3-7. Estimated Water Demands in the Atascadero Subbasin for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	1,348	11,735	0	430	2,032	15,545
Estimated 1997 Demand	(acre-feet)	1,023	11,376	0	300	1,800	14,499
Difference (2006 less 1997)	**(acre feet)**	**325**	**359**	**0**	**130**	**232**	**1,046**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009) and Agricultural Commissioner records in 2006

2006 Municipal demand includes City of Paso Robles groundwater pumping from river wells in the subbasin (3,933 acre-feet)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Study (Fugro 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.

Small community demands included in rural domestic demand

Beginning in 2011, Nacimiento Pipeline will begin delivering surface water to the Atascadero Mutual Water Company (up to 2,000 acre-feet per year) and the Templeton Community Services District (up to 250 acre-feet per year) to offset some of the municipal groundwater pumping.

3.8.2 Bradley Subarea

The Bradley Subarea is located along the northwestern portion of the Paso Robles Groundwater Basin and has an area of approximately 55,500 acres, which makes up about 11 percent of the area of the Basin. Much of the subarea is located in Monterey County. The Salinas River flows northwest through the subarea. The Nacimiento River and the San Antonio River drain the western portion of the Basin. Several creeks draining the North Gabilan Subarea flow into the Salinas River within the subarea. Highway 101 parallels the Salinas River through the subarea. Much of the subarea south of the San Antonio River is within the limits of Camp Roberts.

The water use in 2006 totaled about 7,226 acre-feet representing about eight percent of the water use in the Basin. The water users in the Bradley Subarea and their uses are shown in Table 3-8. All water demands in the subarea are met with groundwater, and the total demand has increased by about 1,000 acre-feet between 1997 and 2006 as shown on Table 3-8.

Table 3-8. Estimated Water Demands in the Bradley Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	6,933	0	0	184	109	7,226
Estimated 1997 Demand	(acre-feet)	6,001	0	0	136	88	6,225
Difference (2006 less 1997)	**(acre feet)**	**932**	**0**	**0**	**48**	**21**	**1,001**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Study (Fugro 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.

3.8.3 Creston Subarea

The Creston Subarea is located in the southern portion of the Paso Robles Groundwater Basin and has an area of approximately 57,000 acres, which makes up about 11 percent of the area of the Basin. The Rinconada fault separates the Creston Subarea from the Atascadero Subbasin. The Huerhuero Creek flows northwest through the subarea, entering the Estrella Subarea southeast of the City of Paso Robles. This subarea includes the community of Creston. There are no public water purveyors in the subarea.

The water use in 2006 totaled about 12,311 acre-feet representing about 14 percent of the water use in the Basin. The primary use of groundwater in this subarea is for agriculture, with rural uses making up most of the remaining water use. Water demands in the Creston Subarea increased by about 1,800 acre-feet during the 1997 to 2006 period as shown on Table 3-9.

Table 3-9. Estimated Water Demands in the Creston Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	9,936	0	0	37	2,338	12,311
Estimated 1997 Demand	(acre-feet)	8,600	0	0	27	1,880	10,507
Difference (2006 less 1997)	**(acre-feet)**	**1,336**	**0**	**0**	**10**	**458**	**1,804**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Study (Fugro 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.

3.8.4 Estrella Subarea

The Estrella Subarea is located in the western portion of the Paso Robles Groundwater Basin and has an area of approximately 82,500 acres, which makes up about 16 percent of the area of the Basin. This subarea includes the City of Paso Robles (City) and the San Miguel Communities Services District. The Salinas River flows north, roughly paralleling Highway 101. Huerhuero Creek enters the subarea from the Creston Subarea and flows into the Salinas River near the City of Paso Robles. The Estrella River flows from the Shandon Subarea and enters the Salinas River north of the City.

The water use in 2006 totaled about 34,077 acre-feet representing about 38 percent of the water use in the Basin. The water users in the Estrella Subarea and their uses are shown in Table 3-10. In 2006, the entire demand was met with groundwater. There is a diverse group of water users in this subarea. About two-thirds of the pumping in this subarea is for agricultural uses. Rural and municipal users account for about one-third of the groundwater pumping. Water demands in the Estrella Subarea increased by about 6,300 acre-feet during the 1997 to 2006 period as shown on Table 3-10.

Table 3-10. Estimated Water Demands in the Estrella Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	23,111	3,930	0	1,603	5,433	34,077
Estimated 1997 Demand	(acre-feet)	20,004	2,137	0	1,186	4,368	27,695
Difference (2006 less 1997)	**(acre feet)**	**3,107**	**1,793**	**0**	**417**	**1,065**	**6,383**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Supply (Fugro, 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.

1997 Municipal demand includes City of Paso Robles groundwater pumping from basin wells (1,911 acre-feet)

Small community demands included in rural domestic demand

Beginning in 2011, up to 4,000 acre-feet of surface water from the Nacimiento Pipeline will be available to the City of Paso Robles to offset some of the municipal groundwater pumping. The City will not be able to use this supply until a water treatment plant is constructed, which is anticipated to come on-line by 2013.

3.8.5 North Gabilan Subarea

The North Gabilan Subarea is located along the northeastern portion of the Paso Robles Groundwater Basin. The North Gabilan Subarea has an area of approximately 52,600 acres, which makes up about 11 percent of the area of the Basin. Almost all of the North Gabilan Subarea is located in Monterey County.

The water use in 2006 totaled about 1,808 acre-feet representing about two percent of the water use in the Basin. The water users in the North Gabilan Subarea and their uses are shown on Table 3-11. Water demands in the North Gabilan Subarea have increased by total of about 250 acre-feet between 1997 and 2006 as shown on Table 3-11.

Table 3-11. Estimated Water Demands in the North Gabilan Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	1,758	0	0	0	51	1,808
Estimated 1997 Demand	(acre-feet)	1,522	0	0	0	41	1,563
Difference (2006 less 1997)	**(acre-feet)**	**236**	**0**	**0**	**0**	**10**	**246**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Study (Fugro 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.

3.8.6 San Juan Subarea

The San Juan Subarea is located in the southeastern portion of the Paso Robles Groundwater Basin and has an area of approximately 84,000 acres, which makes up about 17 percent of the area of the Basin. The San Juan Subarea lies south-southeast of Shandon and includes the agricultural land along San Juan Creek, Camatta Canyon, Shell Creek Road, and Shedd Canyon. These creeks flow northward through the subarea where they eventually become part of the Estrella River in the Shandon Subarea.

The water use in 2006 totaled about 5,452 acre-feet representing about six percent of the water use in the Basin. The water users in the San Juan Subarea and their uses are delineated in Table 3-12. Water demands in the San Juan Subarea are met by groundwater. The demands have increased by a total of about 740 acre-feet between 1997 and 2006 as shown on Table 3-12.

Table 3-12. Estimated Water Demands in the San Juan Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	5,347	0	0	0	105	5,452
Estimated 1997 Demand	(acre-feet)	4,628	0	0	0	84	4,712
Difference (2006 less 1997)	**(acre-feet)**	**719**	**0**	**0**	**0**	**21**	**740**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Study (Fugro 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County

3.8.7 Shandon Subarea

The Shandon Subarea is located in the eastern portion of the Paso Robles Groundwater Basin and has an area of approximately 74,800 acres, which makes up about 15 percent of the area of the Basin. This subarea includes the communities of Whitley Gardens and Shandon. Cholame Creek enters the Basin from the northeast flowing westward. It is joined by the San Juan Creek which flows northward from the San Juan Subarea, near the town of Shandon to form the Estrella River, which then flows west and northwest through the Estrella Subarea and enters the Salinas River north of the City of Paso Robles.

The water use in 2006 totaled about 11,170 acre-feet representing about 12 percent of the water use in the Basin. The water users in the Shandon Subarea and their uses are delineated in Table 3-13. Water demands in the Shandon Subarea met by groundwater increased by about 1,600 acre-feet during the 1997 to 2006 period as shown on Table 3-13.

Table 3-13. Estimated Water Demands in the Shandon Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	9,896	0	0	69	1,205	11,170
Estimated 1997 Demand	(acre-feet)	8,566	0	0	51	969	9,586
Difference (2006 less 1997)	**(acre-feet)**	**1,330**	**0**	**0**	**18**	**236**	**1,584**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Study (Fugro 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County

3.8.8 South Gabilan Subarea

The South Gabilan Subarea is located along the northeastern portion of the Paso Robles Groundwater Basin. The South Gabilan Subarea has an area of approximately 44,500 acres, which makes up about nine percent of the area of the Basin. The northern portion of the South Gabilan Subarea is located in Monterey County. The South Gabilan Subarea is drained by several small creeks that flow into the Estrella River; the small creeks draining the North Gabilan Subarea flow into the Salinas River.

The water use in 2006 totaled about 1,884 acre-feet representing about two percent of the water use in the Basin. The water users in the South Gabilan Subarea and their uses are shown on Table 3-14. Water demands in the South Gabilan Subarea have increased by total of about 250 acre-feet between 1997 and 2006 as shown on Table 3-14.

Table 3-14. Estimated Water Demands in the South Galiban Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	1,671	0	0	0	213	1,884
Estimated 1997 Demand	(acre-feet)	1,446	0	0	o	171	1,617
Difference (2006 less 1997)	**(acre-feet)**	**225**	**0**	**0**	**0**	**42**	**267**

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands from Paso Robles Groundwater Basin Study (Fugro 2002).

Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County

4 Goals and Objectives

Groundwater management involves understanding the available groundwater resources in order to make informed decisions about meeting existing and future water needs. This section establishes the goals and objectives that will be used to direct groundwater management activities.

4.1 Overview of Basin Management Objectives

The State advocates the concept of Basin Management Objectives (BMOs) that are locally-developed guidelines for groundwater management that describe actions to be taken by well owners in response to well-monitoring data. The BMOs allow for more generalized objectives to be developed that are quantified and measureable so that improvements in groundwater management can be tracked and monitored. The BMO concept was also developed to meet the groundwater management needs within a basin that has different groundwater users and/or overlapping jurisdictional agencies. This approach allows the BMO concept to overcome some of the common difficulties associated with defining safe yield and overdraft in a groundwater Basin.

A feature of the BMO method includes the flexibility to modify management objectives as knowledge of the Basin increases. Each area can set its own BMO for one or more wells within the area and pursue its specific groundwater management goals as long as they do not negatively affect neighboring areas. This is a key concept of BMO development – that water management practices or activities in one management area should not negatively affect the water management objectives of another area.

The BMO method of management seeks to protect the Basin from:

- Unacceptable depletion of groundwater in storage
- Degradation of groundwater quality
- Inelastic land subsidence, which is a permanent lowering of the ground surface resulting from compaction of geologic materials caused by groundwater extraction.

4.2 Development of BMOs and GMAs

The groundwater level data collected by the County is the most comprehensive groundwater-related data set in the Basin. Additionally, the stakeholders identified groundwater level declines as the most pressing issue in the Basin. These two factors lead to the determination that at this time, BMOs would be developed for groundwater levels. In addition to groundwater levels affecting total groundwater in storage, groundwater levels are also used as a surrogate for potential groundwater quality impacts and land subsidence impacts associated with groundwater level decline.

In the future, specific BMOs may be developed for groundwater quality and land subsidence when more data is available for either of those subjects.

4.2.1 BMO Workshops

Three workshops were held to meet with the stakeholders in each subarea to review the available information, develop draft BMOs, and identify some activities that could be implemented to meet the BMOs.

The workshops were as follows:

> BMO Workshop No. 1 – April 11, 2010: for the Atascadero, Creston, and Estrella Subareas
>
> BMO Workshop No. 2 – May 10, 2010: for the Bradley and North Gabilan Subareas
>
> BMO Workshop No. 3 – May 10, 2010: for the San Juan, Shandon, and South Gabilan Subareas

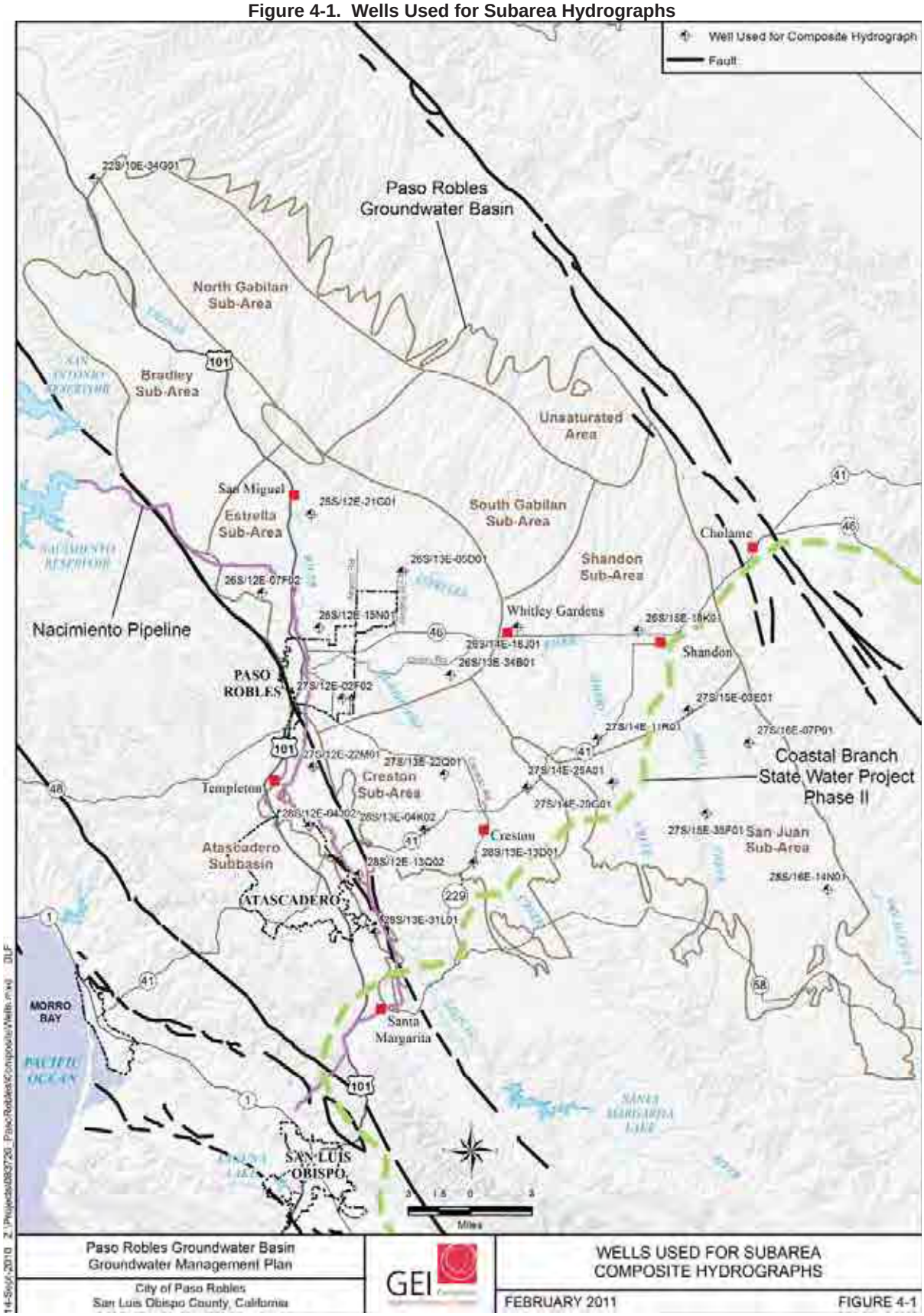
Each of the workshops was well attended by interested parties and stakeholders from each subarea. The list of attendees for the BMO workshops is included in Appendix D. Each subarea stakeholder was provided a packet of subarea-specific information that was used to support the development of BMOs and identification of groundwater management activities (GMAs).

A summary document was produced following the workshops and distributed to the stakeholders for review and comment. The results of the BMO workshops were used to develop the BMOs described below.

4.2.2 BMO Key Wells and Subarea Hydrographs

As part of the development of groundwater level BMOs, key wells were identified within the each subarea to establish the representative groundwater levels that will be used to monitor the change in groundwater levels. Since the Paso Robles Basin groundwater monitoring network is voluntary, there is a limited amount of information that is available to identify key wells. The key wells were selected based on number of monitoring observations during the 1981 to 2009 period of record and the geographic location within the subarea. The wells meeting these two criteria were identified as key wells and used to develop the subarea hydrographs. The locations of these key wells used to create the subarea-specific BMO hydrographs are shown on Figure 4-1.

Figure 4-1. Wells Used for Subarea Hydrographs



4.2.3 Groundwater Management Activities

Groundwater Management Activities (GMAs) are intended to identify the steps or actions taken to meet the BMOs. It should be recognized that both BMOs and GMAs should be evaluated and updated routinely (every few years) as additional information is collected or in response to changing conditions.

4.3 General Basin Management Objectives

The goal of the GMP is to locally manage and protect groundwater resources for all beneficial uses in a long-term sustainable, environmentally sound, economical, and equitable manner. For purposes of meeting the goals of groundwater management stated in Section 2.3 the agencies and stakeholders will support the Basin Management Objectives described in this section. Two sets of BMOs have been developed reflecting the regional nature of this groundwater management plan: (1) broad level BMOs are designed to have basin-wide, regional perspectives [Section 4.3], and (2) more specific BMOs have been developed for each Subarea [Section 4.4].

4.3.1 Maintain and Improve Groundwater Levels

Groundwater levels in the basin generally reflect the overlying level of development of all use types (agricultural, municipal, small commercial, small community, and rural domestic). Groundwater levels have experienced the greatest levels of decline in the areas with the highest level of development, and near the center of those areas with the greatest level of development. This objective is intended to ensure that the overall groundwater levels in the basin are maintained to provide long-term reliable sources of water for the economic well-being of the area. General activities and projects that maintain and improve groundwater levels include projects that:

- Reduce groundwater pumping
- Increase overall water supply
- Increase water reuse or recycled water supply
- Protect and increase groundwater recharge
- Limit future increases in groundwater pumping

Some of the considerations for implementing these activities to improve groundwater levels are summarized on Table 4-1, including agencies that may be responsible for implementation of the various projects, the relative cost and schedule for the projects, and the overall implementation complexity.

Table 4-1. Implementation of GMAs to Maintain and Improve Groundwater Levels

Groundwater Management Activity	Implementation Considerations			
	Implementation Responsibility	Relative Implementation Schedule	Relative Implementation Cost	Overall Implementation Complexity
Potential activities to reduce groundwater pumping:				
1) Reduce agricultural pumping	Individual Growers	Short	low-medium	low-medium
2) Reduce municipal pumping	Urban Purveyors Customers	Ongoing	low-medium	low-medium
Potential activities to increase water supply:				
1) Import Nacimiento Project Water	Organized Water Purveyors	Short (6 months) to medium (2-3 years)	high	high
2) Import State Water Project Water	Organized Water Purveyors	Long - More than 10 years	high	high
Potential reuse or recycled water projects:				
1) Implement agricultural water reuse program	Individual Growers	Additional savings generally not feasible because use of drip irrigation	low-medium?	low-medium?
2) Increase municipal water recycling program	Organized Water Purveyors	Long - More than 10 years	high	high
Potential groundwater recharge projects:				
1) Protect natural recharge areas	Organized Water Purveyors / Landowners	Medium to long	Medium - high	Medium - high
2) Recharge imported surface water	Organized Water Purveyors	Long - More than 10 years	high	high
3) Recharge municipal reclaimed water	Organized Water Purveyors	Long - More than 10 years	high	high
4) Recharge storm water	Organized Water Purveyors / Landowners	Medium to long	medium - high	high
Manage future increases in groundwater pumping:				
1) Land use planning policies that do not allow net increase in groundwater pumping	County/City			

4.3.2 Maintain and Improve Groundwater Quality

The general water quality of the groundwater basin with respect to general minerals and selected minor constituents is good, but there are some areas of rising concentrations of total dissolved solids (TDS), chloride, and nitrate. Potential sources of these constituents include wastewater discharges (septic and municipal), agricultural practices, and irrigation with recycled water. General activities and projects that maintain and improve groundwater quality include projects that:

- Protect the water quality in the confined aquifer from by ensuring the proper construction of groundwater wells, including seals to separate the aquifer systems.
- Limit the impacts of the migration of contamination groundwater by incorporating available groundwater quality data into groundwater management operations.
- Limit upwelling of groundwater from the deeper aquifers by maintaining groundwater levels.

4.3.3 Protect Against Potential Inelastic Land Surface Subsidence

Historically, no land surface subsidence has been identified within the Basin. General activities and projects that protect against inelastic land subsidence resulting from groundwater level declines include those projects that maintain and improve groundwater levels. Additional activities could include projects that:

- Coordinate potential future land subsidence monitoring opportunities with State and federal agencies.
- Manage the groundwater basin to prevent land subsidence.
- Adjust groundwater management activities if land subsidence resulting from declining groundwater level is identified.

4.3.4 Protect Against Adverse Impacts to Surface Water Flows

Except along the Salinas River, there is little information regarding the relationship and interaction between surface water and groundwater in the Basin. There are few, if any, perennial streams in the Basin. Information on this relationship is needed to develop an understanding of the implications on the recharge/discharge areas and water quality conditions. General activities and projects that improve the understanding of groundwater and surface water interaction include projects that:

- Monitor river stage and nearby unconfined groundwater levels along the Salinas River.
- Evaluate this information to understand the relationship between surface water flows and groundwater levels at specific locations to determine the effect on groundwater levels and quality, including the potential impact of agricultural return flows on groundwater quality (to the extent any exist within the basin) and runoff from rural residences, horse pastures, roads, etc.

4.3.5 Groundwater Monitoring and Assessment

Groundwater monitoring provides the data and information needed to make groundwater management decisions. Groundwater level monitoring program is currently conducted by San Luis Obispo County. The California Statewide Groundwater Elevation Monitoring Program was created by legislation SBx7-6 in 2009. It will formalize how groundwater levels are reported to the State.

Current groundwater monitoring efforts include participation by various local districts and purveyors and San Luis Obispo County. An updated Monitoring Plan was developed for this GMP and is included in Appendix E.

The Monitoring Plan identifies the extent of the existing groundwater monitoring program in the unconfined and confined aquifer systems for groundwater elevations. The Monitoring Plan was prepared based on the existing wells monitored by several different agencies in the basin and provided recommendations for additional groundwater elevation and quality monitoring. This plan will be implemented by the GAC member agencies. Specific activities and projects that improve groundwater monitoring and assessment of groundwater conditions include projects that:

- Implement the Monitoring Plan included in Appendix E.
- Fill the data gaps in the Monitoring Plan with new dedicated multi-completion monitoring wells (if funding is available).

4.3.6 Evaluate and Implement Feasible Water Conservation Measures

Certain water conservation practices may be evaluated to determine their ability to improve water levels and water quality in the Basin. These may include water conservation opportunities for all land use types (agricultural, municipal, small commercial, small community, and rural domestic). General activities that support improved water demand management and water conservation include projects that:

- Identify current and potential conservation practices for each land use type.
- Quantify existing conservation practices being implemented.
- Develop outreach programs to encourage water conservation.
- Identify water reuse and water recycling opportunities
- Identify potential Low Impact Development (LID) opportunities for existing and new residential and commercial developments
- Provide incentives for water conserving devices/practices.

4.4 Subarea Basin Management Objectives

This section describes the identification of the groundwater level BMOs for individual subareas within the Basin.

The groundwater level BMOs established by the stakeholders for each subarea are listed in Table 4-2. In general, BMOs were selected to maintain or stabilize groundwater levels at or

near current conditions. Several subareas identified this as the initial BMO with the expectation that stabilizing groundwater levels needed to be achieved before improving groundwater levels could be considered.

Table 4-2. Basin Management Objective by Subarea

Subarea/Subbasin	Basin Management Objective (BMO)
Atascadero	Stabilize groundwater levels at 2009 levels
Bradley	Maintain groundwater levels
Creston	Stop decline and stabilize levels at 2009 levels
Estrella	Stabilize groundwater levels
North Gabilan	Maintain groundwater levels
San Juan	Maintain groundwater levels
Shandon	Stabilize groundwater levels
South Gabilan	Maintain groundwater levels

The initial Groundwater Management Activities identified during the stakeholder workshops are listed on Table 4-3. Many of the GMAs identified are common to several subareas. The subarea descriptions that follow include more detailed information about the draft BMOs and GMAs identified by the stakeholders through the workshops.

Table 4-3. Identified Groundwater Level GMAs by Subarea

Subarea/ Subbasin	Increase monitoring and reporting	Increase water conser-vation	Manage Growth	Use Nacimiento Project Water	Cloud-seeding	Prevent export from basin	Ground-water recharge and banking	Use State Water Project Water	Form irrigation or water district
Atascadero	X	X	X	X			X		
Bradley	X				X				
Creston	X	X	X			X	X		
Estrella	X	X		X					
North Gabilan									
San Juan	X								
Shandon		X			X		X	X	X
South Gabilan									

4.4.1 Atascadero Subbasin

The changes in groundwater levels in the Atascadero Subbasin are currently recorded at 51 wells that are included in the groundwater monitoring network. Four of these wells were selected to be representative of changes in groundwater level conditions in the subbasin. The locations of these four wells are shown on Figure 4-1.

The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Atascadero Subbasin is included in Figure 4-2. This figure shows that in a single year, the average groundwater level can increase or decrease by up to 15 feet. The overall trend of the average groundwater levels has remained relatively constant since the early 1980s with groundwater levels rising and falling primarily in response to changing hydrologic conditions and increasing demands.

Representative precipitation data for the Atascadero Subbasin is recorded at the Atascadero Mutual Water Company precipitation Gage # 34. Precipitation data is available for this gage for the 1931 to 2009 period, during which annual precipitation averaged 17.65 inches. The annual rainfall for 1981 to 2009 period was about average (17.58 inches) compared to the period of record at that gage.

Figure 4-2. Atascadero Subbasin Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	Atascadero
Basin Name	Atascadero

Sub-Area Well Records	
Period of Record	1966-2009
Num. BMO Wells	4

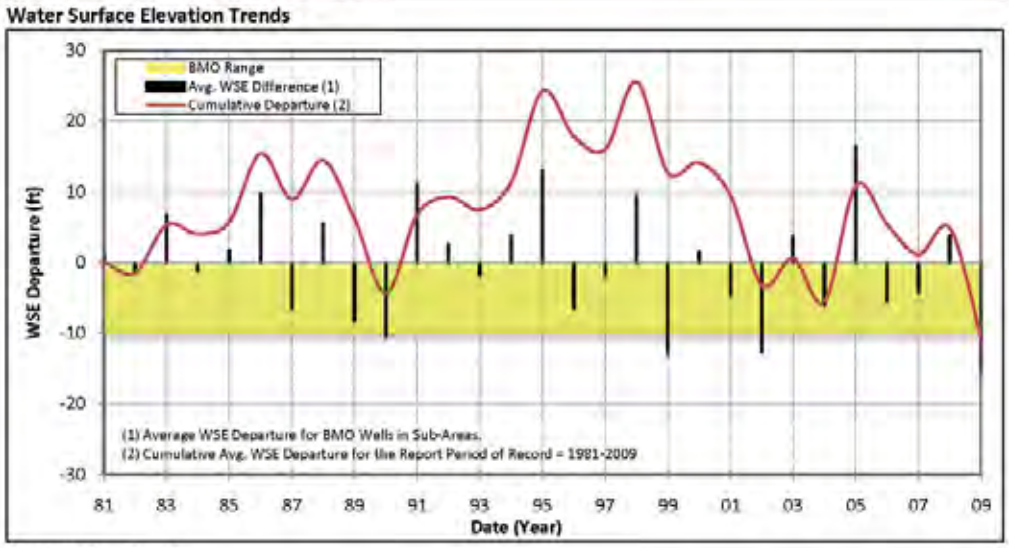
Report Information	
Report Start Year	1981
Period of Record	1981-2009

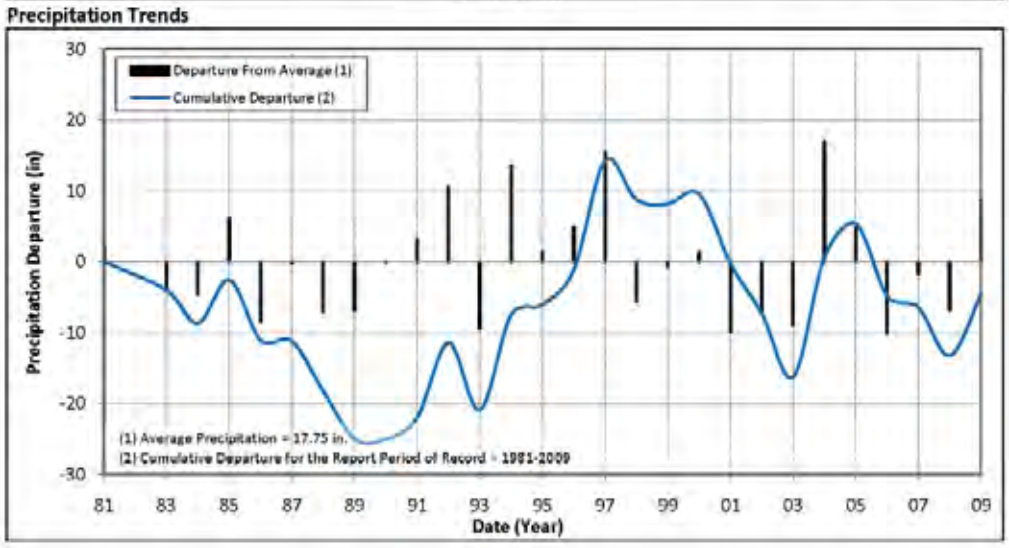
Raingage Information	
Raingage Name	Atas. Mutual Water # 34
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1966-2009
Average Precip.	17.64 in

Trend Analysis Results	
BMO Departure[1]	(10.00 ft)
2009 Departure	(10.75 ft)

NOTES: 1) BMO Cumulative Departure Since 1981





Based in part on this information, the stakeholders representing the Atascadero Subbasin determined that an acceptable draft BMO for groundwater levels that would include stabilizing groundwater levels at about the 2009 level. This represents a decline of about 10 feet from the 1981 groundwater levels as shown on Figure 4-2.

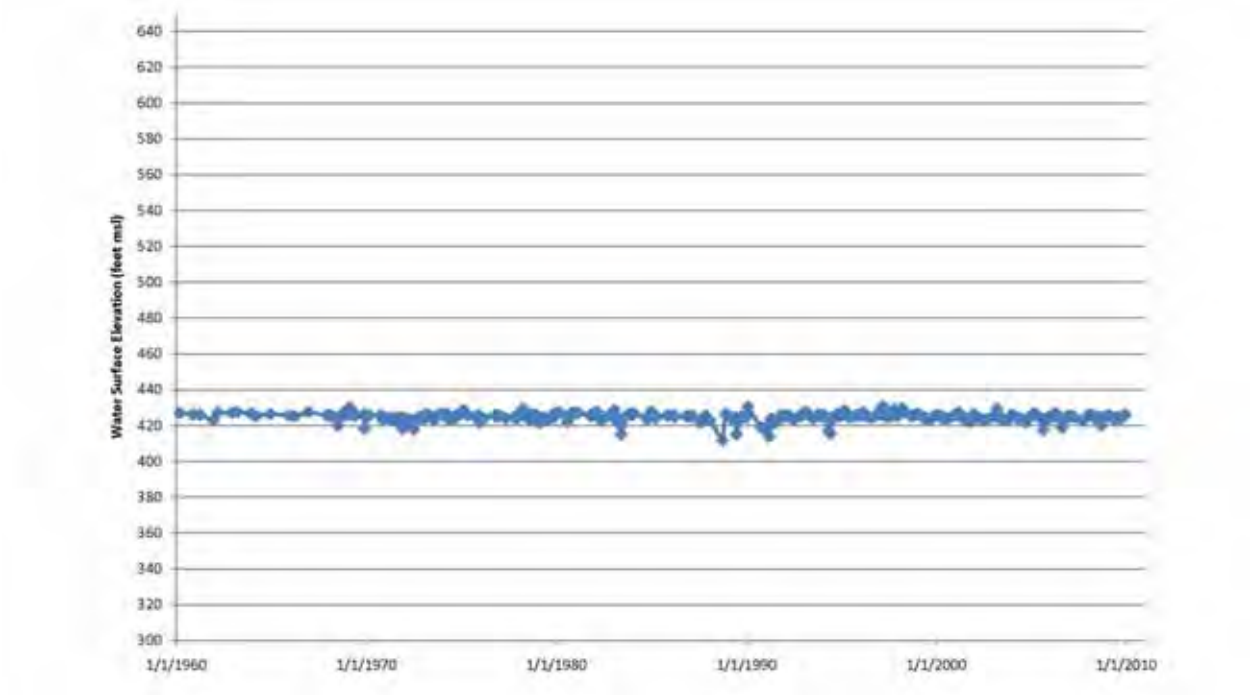
The following actions GMAs were identified by the stakeholders to stabilize groundwater levels in the Atascadero Subbasin. The GMAs are briefly described below.

- **Increase monitoring and reporting on groundwater conditions:** This GMA includes expanding the groundwater monitoring network in the Atascadero Subbasin through the addition of new wells to the volunteer monitoring network.
- **Increase water conservation education and implementation**: This GMA includes increasing the awareness of the impact of water conservation on reducing groundwater pumping. The effectiveness of the water conservation program will be difficult to verify for rural and agricultural areas without metering well production. The effectiveness of the GMA will be based on the changing behavior of individual water users and impacts on groundwater level trends in the area. The effectiveness of this GMA will be evaluated on an annual basis.
- **Managing the growth and corresponding increase in water demands**: This GMA includes identifying potential land use planning activities that may be used to reduce the rate of growth of water demand in the subbasin. In areas outside the jurisdiction of the cities of Atascadero and Paso Robles, land use planning is the responsibility of the San Luis Obispo County Department of Planning and Building.
- **Maximize the amount of Nacimiento Project Water in the Subbasin**: This GMA includes utilizing the existing Nacimiento Project Water already acquired for use in the subbasin, and explore opportunities to utilize unassigned Nacimiento Project Water.
- **Consider storm water management opportunities to increase local groundwater recharge**: This GMA includes evaluating the feasibility of recharging storm water runoff in the streams and creeks of the Basin. The potential benefit (in groundwater recharge) has not been evaluated for this GMA at this time.

4.4.2 Bradley Subarea

The changes in groundwater levels in the Bradley Subarea are currently recorded at one well that is included in the groundwater monitoring network of Monterey County Water Resources Agency (MCWRA). Construction details for this well are unknown and it may not be representative of groundwater levels throughout the Bradley or North Gabilan Subareas. The lack of data prevents the development of groundwater level hydrographs or composite hydrographs as developed for other subareas. The lone hydrograph available for these two subareas is shown in Figure 4-3. The location is shown on Figure 4-1.

Figure 4-3. Well Hydrograph in the Bradley Subarea



The hydrograph shown in Figure 4-3 is for a well located near the Salinas River downstream of the confluence of the Salinas River and the Nacimiento River. It appears that groundwater levels in this well reflect the interaction of the Salinas River and the alluvial aquifer materials adjacent to the river. Flows from the Salinas River, along with releases from Nacimiento Reservoir, help maintain groundwater levels in the alluvial aquifer near the Salinas River.

At this time, we are not aware of any reports or anecdotal information that suggests groundwater levels in the Bradley Subarea is declining to the point of causing problems for local groundwater users.

The different levels of BMOs were discussed at the workshop. As described above, there is very little available information to support the development of much targeted BMOs. Based on the available information, the BMO for the Bradley Subarea is to maintain high groundwater levels. The lack of an extensive monitoring network in this part of the Basin will prevent more detailed analysis at this time.

- **Continue monitoring and reporting on groundwater conditions:** Continue and improve monitoring – look to add monitoring well near the San Luis Obispo-Monterey County boundary between the Nacimiento River and the town of San Miguel.
- **Consider reestablishing Cloud Seeding Program:** Consider benefits of re-establishing the cloud seeding program in the Nacimiento and San Antonio watersheds. Cloud seeding was conducted in the past by MCWRA, and is estimated to have increased inflow into Lake Nacimiento and San Antonio Reservoirs by about 20 percent.

4.4.3 Creston Subarea

The changes in groundwater levels in the Creston Subarea are currently recorded at 17 wells that are included in the groundwater monitoring network. Four of these wells were selected to be representative of changes in groundwater level conditions in the eastern portion of the subarea. The locations of these four wells are shown on Figure 4-1. Since a well was not available in the northwestern portion of the subarea where well levels have declined most dramatically, these wells are not representative of the entire subarea.

The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Creston Subarea is shown on Figure 4-4. This figure shows the average groundwater levels in the subarea appear to have peaked at about 1999. Since this time, groundwater levels have generally declined. This may be due in part to the increase in water demands between 1997 and 2006.

Representative precipitation data for the Creston Subarea is recorded at the Erickson Ranch precipitation Gauge # 52.1. Precipitation data is available for this gauge for the 1928 to 2009 period, during which annual precipitation averaged 11.89 inches. The annual rainfall for the 1981-2009 period was about one inch higher on average (12.85 inches) compared to the period of record at that gauge.

Based in part upon this information, the stakeholders representing the Creston Subarea determined that an acceptable draft BMO for groundwater levels in the Creston Subarea would include stopping the current rate of decline experienced in the last 10 years, and stabilizing groundwater levels at about the 2009 level as presented in the composite hydrograph (average of four wells) in the next five to ten years.

Figure 4-4. Creston Subarea Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	Creston
Basin Name	Paso Robles

Sub-Area Well Records	
Period of Record	1960-2009
Num. BMO Wells	4

Report Information	
Report Start Year	1981
Period of Record	1981-2009

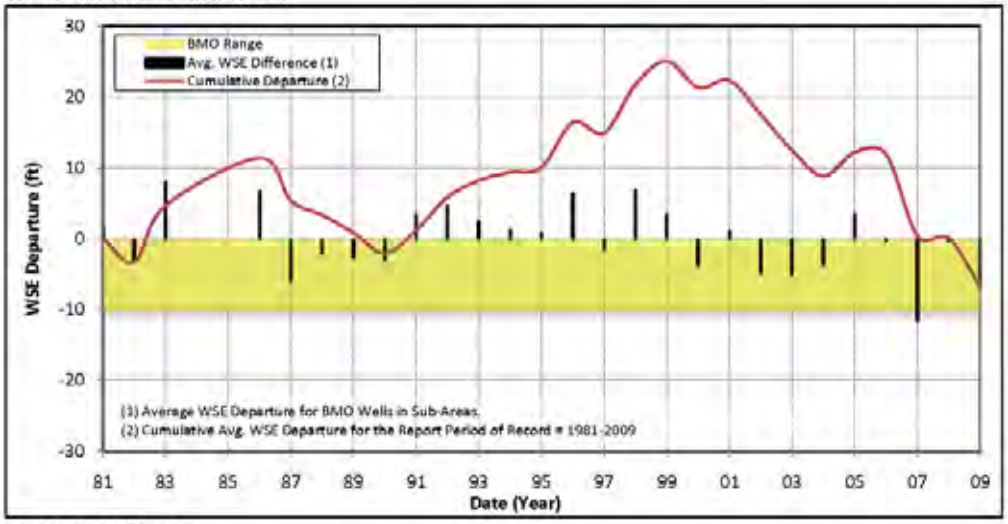
Raingage Information	
Raingage Name	Atas. Mutual Water # 34
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1960-2009
Average Precip.	17.64 in

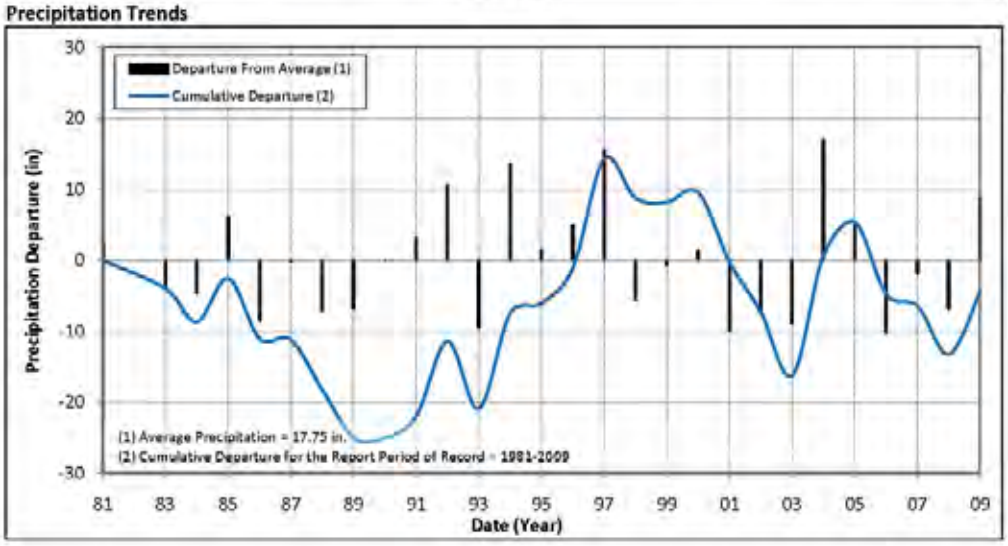
Trend Analysis Results	
BMO Departure[1]	(10.00 ft)
2009 Departure	(6.91 ft)

NOTES: 1) BMO Cumulative Departure Since 1981

Water Surface Elevation Trends



Precipitation Trends



The following GMAs were identified by the Creston Subarea stakeholders to stabilize groundwater levels in the Creston Subarea.

- **Increase monitoring and reporting on groundwater conditions**: This GMA includes expanding the groundwater monitoring network in the Creston Subarea through the addition of new wells to the volunteer monitoring network. Additional wells are needed in the northwest portion of the subarea near the Estrella Subarea where historic groundwater level decline has been the greatest.
- **Increase water conservation education and implementation**: This GMA includes increasing the awareness of the impact of water conservation on reducing groundwater pumping. The effectiveness of the water conservation program will be difficult to verify for rural and agricultural areas without metering well production. The effectiveness of the GMA will be based on the changing behavior of individual water users and stabilized groundwater levels. The effectiveness of this GMA will be evaluated on an annual basis.
- **Managing the growth and corresponding increase in water demands**: This GMA includes identifying potential land use planning activities that may be used to reduce the rate of growth of rural residential development in the subarea. Throughout this subarea, land use planning is the responsibility of the San Luis Obispo County Department of Planning and Building. This GMA may include:
    - Moratorium on lot splits and subdivisions.
    - No net increase in groundwater use resulting from additional rural residential development via General Plan Amendments.
- **Preventing export of groundwater from the Basin:** This GMA includes identifying potential activities that result in exporting groundwater from the Basin. At this time, additional information is necessary to quantify the occurrence of groundwater pumping for export from the Basin. [to date this has not been quantified]
- **Consider storm water management opportunities to increase local groundwater recharge:** This GMA includes evaluating the feasibility of recharging storm water runoff in the streams and creeks of the Basin, at offstream locations and by retaining storm water onsite. The potential benefit (in groundwater recharge) has not been evaluated for this GMA at this time.

4.4.4 Estrella Subarea

The changes in groundwater levels in the Estrella Subarea are currently recorded at 50 wells that are included in the groundwater monitoring network. Six of these wells were selected to be representative of changes in groundwater level conditions in the subarea. The locations of these six wells are shown on Figure 4-1.

The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Estrella Subarea is shown on Figure 4-5. Groundwater levels steadily declined during the period by over 70 feet.

Representative precipitation data for the Estrella Subarea is recorded at the Paso Robles precipitation Gage # 10. Precipitation data is available for this gage for the 1901 to 2009

period, during which annual precipitation averaged 15.04 inches. The annual rainfall for the 1981 to 2009 period was about one-half inch below average (14.49 inches) compared to the period of record at that gage.

The Estrella Subarea recorded the largest decline in groundwater levels (about 50 feet) during the 1997 to 2009 period. During this time, the average annual precipitation at the Paso Robles Gage was just below average (13.73 inches), suggesting that increased groundwater demands contributed significantly to the decline in groundwater levels in this subarea.

Based on this information, the stakeholders representing the Estrella Subarea determined that an acceptable draft BMO for groundwater levels in the subarea would include stabilizing groundwater levels at about the 2009 level. The goal of recovery of groundwater levels was identified as desirable by private domestic well owners, but the group agreed that such an objective was over-reaching at this time. The following GMAs were identified by the stakeholders to stabilize groundwater levels in the Estrella Subarea.

- **Increase data collection and monitoring and reporting on groundwater conditions:** It was determined that there is enough information to know that there is a problem, however, additional and better information is needed to further understand the problem.
- **Increase water conservation education and implementation:** The stakeholders recognized that additional conservation is needed. Some stakeholders felt that the amount of savings that can be achieved is limited. Other stakeholders felt that additional conservation in the agricultural sector could play a significant role in reducing groundwater demand and achieving the BMO of stabilizing water levels.
- **Nacimiento Project Water:** The stakeholders reached consensus regarding the use of Nacimiento Project Water to help alleviate the groundwater decline problem, but it was also recognized as not being the sole solution.

Figure 4-5. Estrella Subarea Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	Estrella
Basin Name	Paso Robles

Sub-Area Well Records	
Period of Record	1967-2009
Num. BMO Wells	6

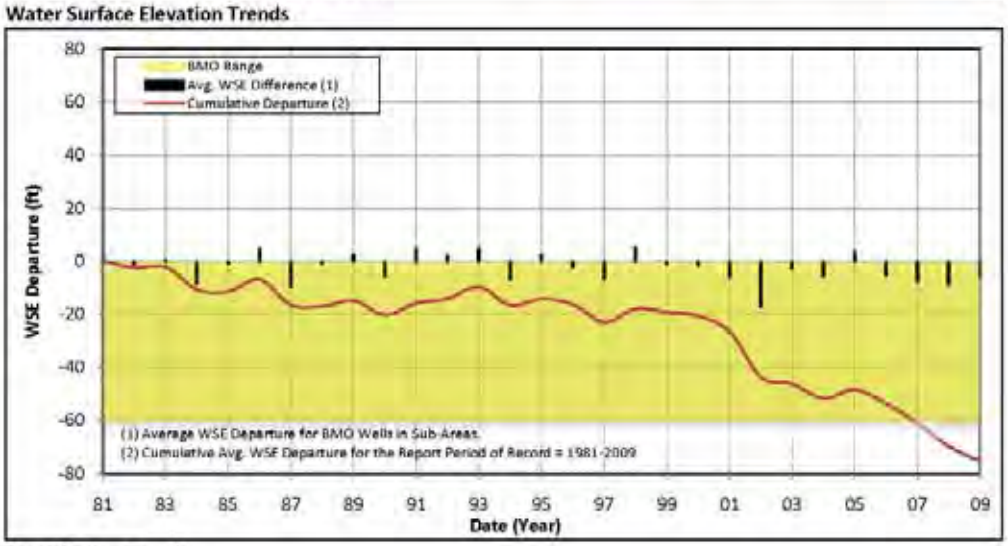
Report Information	
Report Start Year	1981
Period of Record	1981-2009

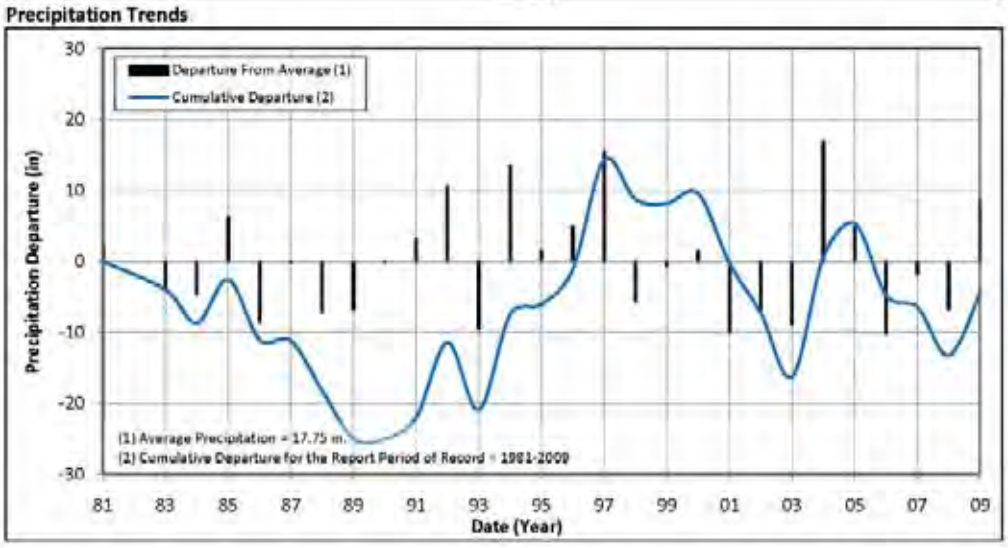
Raingage Information	
Raingage Name	Atas. Mutual Water # 84
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1967-2009
Average Precip.	17.64 in

Trend Analysis Results	
BMO Departure[1]	(60.00 ft)
2009 Departure	(75.43 ft)

NOTES: 1) BMO Cumulative Departure Since 1981





4.4.5 North Gabilan Subarea

Overall water demand and groundwater use is low in the North Gabilan Subarea. There is also limited groundwater level data available, and no data that could be used to represent average groundwater levels in the subarea. Additionally, there are not identified groundwater problems or issues that have been presented to the Groundwater Advisory Committee. Because of the limited available data and identification of groundwater issues in the subarea, it is not practical to identify BMOs that can be measured at this time. The initial GMA

proposed at this time would include additional groundwater level monitoring to begin to track changes in groundwater levels. BMOs and additional GMAs may be developed after additional groundwater level data has been collected.

4.4.6 San Juan Subarea

4.4.6.1 Basin Management Objective

The changes in groundwater levels in the San Juan Subarea are currently recorded at 15 wells that are included in the groundwater monitoring network. Four of these wells were selected to be representative of changes in groundwater level conditions in the subarea. The locations of these four wells are shown on Figure 4-1.

The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the San Juan Subarea is shown on Figure 4-6. This figure shows that the groundwater levels in the San Juan Subarea are highly variable on an annual basis. It appears that groundwater levels in the San Juan Subarea respond quickly to changes in hydrologic conditions, with average groundwater levels increasing or decreasing by as much as 35 feet in a single year.

Representative precipitation data for the San Juan Subarea is recorded at the Shandon precipitation Gage # 73. Precipitation data is available for this gage for the 1937 to 2009 period, during which annual precipitation averaged 10.69 inches. The annual rainfall for 1981-2009 period was about one-half inch above average (11.06 inches) compared to the period of record at that gage.

During the 1981 to 1997 period, average groundwater levels changed considerably on a year-to-year basis, but there was no net significant difference in the cumulative groundwater levels at the end of the 16-year period. During the 1997 to 2006 period, the average groundwater levels in the San Juan Subarea declined by about 20 feet. Finally, during the 2006 to 2009 period, the average groundwater levels declined slightly (less than 5 feet). Overall, during the 1981 to 2009 period, average groundwater levels in the San Juan Subarea declined by about 25 feet.

Figure 4-6. San Juan Subarea Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	San Juan
Basin Name	Paso Robles

Sub-Area Well Records	
Period of Record	1960-2009
Num. BMO Wells	4

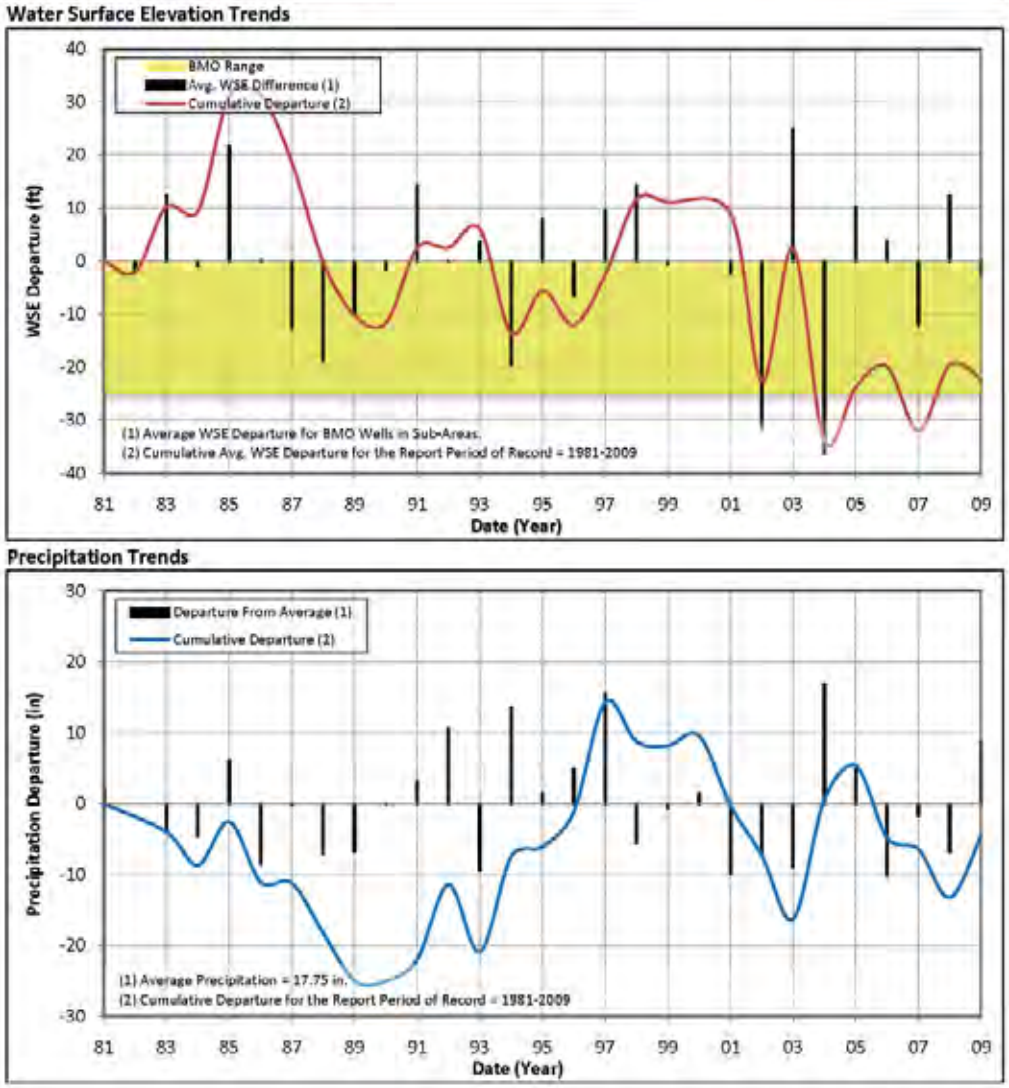
Report Information	
Report Start Year	1981
Period of Record	1981-2009

Raingage Information	
Raingage Name	Atas. Mutual Water # 34
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1960-2009
Average Precip.	17.64 in

Trend Analysis Results	
BMO Departure[1]	(25.00 ft)
2009 Departure	(22.24 ft)

NOTES: 1) BMO Cumulative Departure Since 1981



Based on this information, the stakeholders representing the San Juan Subarea determined that an acceptable draft BMO for groundwater levels in the subarea would include stabilizing groundwater levels at about the 2009 level. The following GMAs were identified by the stakeholders to stabilize groundwater levels in the San Juan Subarea.

- **Continue monitoring and reporting on groundwater conditions:** The stakeholders suggest continuing the groundwater level monitoring and reporting program. The

existing monitoring network provides reasonable coverage for the subarea at this time based upon the current groundwater level conditions. Additional monitoring wells could be added, but are not considered as important as continuing to actively monitor and report on groundwater levels to extend the historical period of record.

4.4.7 Shandon Subarea

The changes in groundwater levels in the Shandon Subarea are currently recorded at 24 wells that are included in the groundwater monitoring network. Four of these wells were selected to be representative of changes in groundwater level conditions in the subarea. The locations of these four wells are shown on Figure 4-1.

The composite hydrograph illustrating the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Shandon Subarea is shown on Figure 4-7.

This figure shows that the average groundwater levels the Shandon Subarea are highly variable on an annual basis. During the 1981 to 1997 period, average groundwater levels in the Shandon Subarea have declined by about 33 feet.

During the 1997 to 2006 period, average groundwater levels fluctuated annually, but resulted in very little net decline (about 2 feet) compared to 1997 levels.

Finally, from 2006 to 2009 period, the average groundwater levels declined by about 30 feet. Overall, during the 1981 to 2009 period (28 years), average groundwater levels in the Shandon Subarea declined by about 65 feet (about 2.3 feet per year), in response to a combination of increasing water demands that are met by groundwater.

Representative precipitation data for the Shandon Subarea is recorded at the Shandon precipitation Gage # 73. Precipitation data is available for this gage for the 1937 to 2009 period, during which annual precipitation averaged 10.69 inches. The annual rainfall for 1981-2009 period was about one-half inch above average (11.06 inches) compared to the period of record at that gage.

Based on this information, the stakeholders representing the Shandon Subarea determined that an acceptable draft BMO for groundwater levels in the subarea would include stabilizing groundwater levels at about the 2009 level, but there was concern about the cost of the program. The following GMAs were identified by the stakeholders to stabilize groundwater levels in the Shandon Subarea.

- **Groundwater Recharge and Banking Programs:** The discussions did not focus on the details of this project or the approach, but did identify potential groundwater recharge or banking of either imported supplies or from storm water runoff as potential sources of groundwater recharge. One potential project that was discussed was an inflatable dam project such as was done along the Salinas River in Northern Monterey County. No additional details were provided on that potential project.

- **State Water Project supplies for Shandon:** The community of Shandon has not used its 100 acre-feet of State Water Project water (SWP) to date. This project would include tying in to the Coastal Branch were it passes through Shandon to access the 100 acre-feet of supply. SWP supplies on the Coastal Branch are treated at the Polonio Pass Water Treatment Plant. This project would reduce municipal groundwater pumping in the Shandon area by the amount delivered from the SWP, thereby reducing groundwater pumping.

  An alternative of this GMA would be to pursue additional SWP supplies that could also be delivered to Shandon. San Luis Obispo County has a contract allocation to additional SWP supplies that it has not used, and is not currently using. These supplies could be a potential source of water to the area. Additional capacity in Phase II of the Coastal Branch would be needed to deliver water in excess of the 100 acre-feet supply currently contracted to Shandon by the County. An investigation regarding the additional capacity of the Coastal Branch is currently being pursued by the District.

- **Formation of Irrigation District or Water District:** The discussion focused on the **potential** need to form an irrigation district or water district to import surface water into the Basin. Irrigation districts/water districts are often formed to pursue large projects that benefit a larger group of water users. Such a district may be formed to pursue a groundwater recharge or water banking project that would rely on imported surface water.

- **Increase water conservation education and implementation:** The stakeholders recognized that additional conservation may result in a water savings, but were not sure if it **would** be cost effective. There was no objection to promoting conservation, and some discussions explored different conservation methods (such as alternative frost-control measures) since most growing operations are already on drip, and landscaping in Shandon is generally modest.

- **Precipitation Enhancement:** This was brought up for discussion, but it was unclear whether this project would work for the Shandon area.

Figure 4-7. Shandon Subarea Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	Shandon
Basin Name	Paso Robles

Sub-Area Well Records	
Period of Record	1967-2009
Num. BMO Wells	4

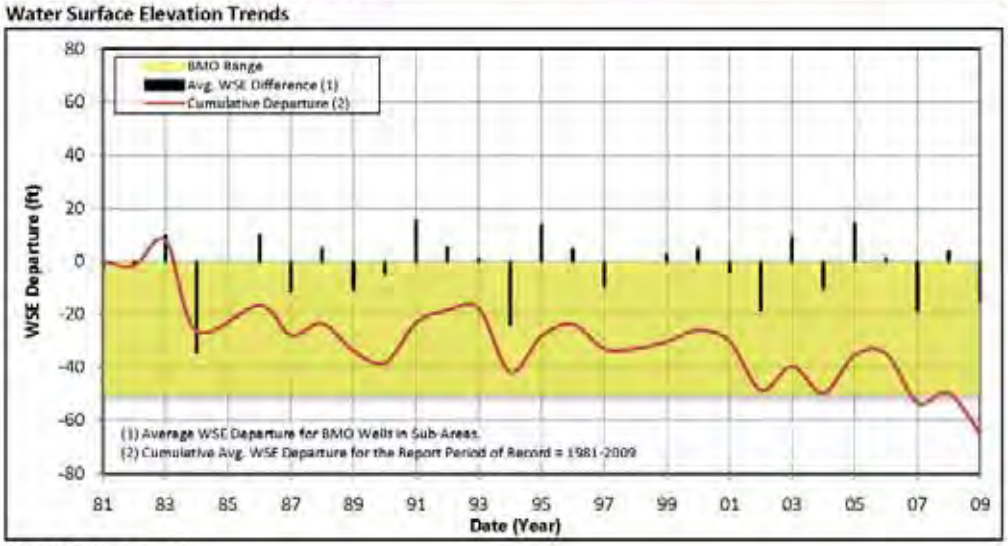
Report Information	
Report Start Year	1981
Period of Record	1981-2009

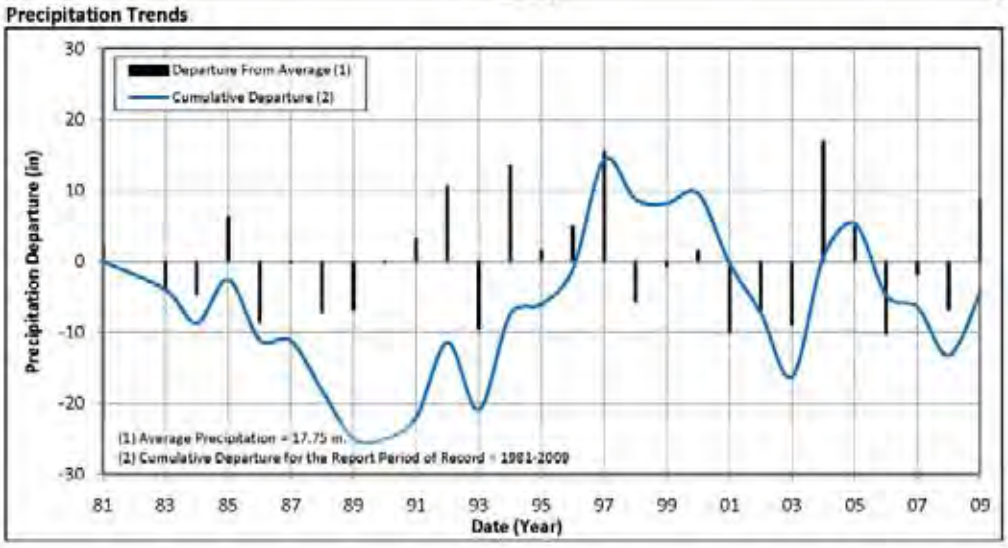
Raingage Information	
Raingage Name	Atas. Mutual Water # 34
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1967-2009
Average Precip.	17.64 in

Trend Analysis Results	
BMO Departure[1]	(50.00 ft)
2009 Departure	(64.99 ft)

NOTES: 1) BMO Cumulative Departure Since 1981





4.4.8 South Gabilan Subarea

Overall water demand and groundwater use is low in the South Gabilan Subarea. There is also limited groundwater level data available, and no data that could be used to represent average groundwater levels in the subarea. Additionally, there are no identified groundwater problems or issues that have been presented to the Groundwater Advisory Committee.

Because of the limited available data and identification of groundwater issues in the subarea, it is not practical to identify BMOs that can be measured at present. The initial GMA proposed at this time would include additional groundwater level monitoring to begin to track changes in groundwater levels. BMOs and additional GMAs may be developed after additional groundwater level data have been collected.

5 Groundwater Management Plan Components

The Plan includes a variety of actions that are required by the Water Code, recommended by DWR Bulletin 118 California's Groundwater (DWR, 2003), and identified as optional programs under the Water Code. These actions are grouped into the following groundwater management components.

1. Stakeholder Involvement
2. Groundwater Monitoring and Data Collection
3. Groundwater Resource Protection
4. Groundwater Sustainability
5. Water Demand Management

The relationship of these components to the Basin Management Objectives identified in Section 4 is presented on Table 5-1. Each of these components is described in more detail in this section.

Table 5-1. Groundwater Management Component Summary

Groundwater Management Components		Basin Management Objectives					
		Maintain and Improve Groundwater Levels	Maintain and Improve Groundwater Quality	Protect Against Potential Inelastic Land Surface Subsidence	Protect Against Adverse Impacts to Surface Water Flows	Groundwater Monitoring and Assessment	Evaluate and Implement Feasible Water Conservation Measures
1. Stakeholder Involvement and Coordination							
1.1	Involvement with Stakeholders and Public	X				X	
1.2	Formation of a GAC for GMP Development and Implementation	X				X	X
1.3	Coordination with other agencies	X	X		X	X	X
1.4	Coordination with other water management planning efforts	X				X	X
2. Groundwater Monitoring and Data Collection							
2.1	Groundwater Elevation Monitoring	X				X	
2.2	Groundwater Quality Monitoring		X			X	
2.3	Inelastic Land Subsidence Monitoring			X		X	
2.4	Data Management System	X	X	X	X	X	X
2.5	Project Reporting	X	X	X	X	X	X
3. Groundwater Resource Protection							
3.1	Well Construction, Abandonment and Destruction Policies		X				
3.2	Wellhead Protection Measures		X				
3.3	Monitor Contaminated and Poor Quality Groundwater		X			X	
3.4	Control of Saline Water Intrusion		X			X	
4. Groundwater Sustainability							
4.1	Replenishment of High Quality Groundwater Extracted by Water Producers	X		X	X		
4.2	Construction and Operation of Recharge, Storage, and Extraction Projects	X	X	X	X		
4.3	Management of Sustained Groundwater Levels	X	X	X	X		
4.4	Modeling and Technical Analysis	X				X	X
5. Water Demand Management and Conservation							
5.1	Agricultural Water Management Practices	X	X				X
5.2	Urban Water Management Practices	X	X				X
5.3	Rural residential Water Management Practices	X	X				X

5.1 Component 1 – Stakeholder Involvement and Coordination

This component outlines the ongoing processes that will be used during the implementation of the Plan to involve stakeholders and coordinate with appropriate agencies involved in groundwater management activities in the Basin. A Governance Subcommittee was formed during the development of the Plan to consider the potential governance process for the implementation of the Plan. The subcommittee met on January 6, 2011. The results of the subcommittee meeting are described below.

5.1.1 Steering Committee

The Governance Subcommittee determined that a Steering Committee would be formed with the purpose of facilitating the implementation of the Plan. The Steering Committee would consist of 15 representatives from (one from each entity):

- Cities of Atascadero and Paso Robles
- Atascadero Mutual Water Company, Templeton CSD, San Miguel CSD – if they each choose to send a representative
- SLO County (Flood Control and Water Conservation District)
- Paso Robles Wine Country Alliance
- Central Coast Vineyard Team
- SLO County Farm Bureau
- SLO Cattlemen's Association
- PRIOR
- Four general At-Large positions, trying to balance vineyards, other agriculture, and rural residential

The qualifications for membership on the Steering Committee would include being a stakeholder or representative of a stakeholder group, years of relevant experience, and demonstrated commitment to the process. The listed agencies and organizations will select their representatives.

The Steering Committee would meet monthly at the beginning of the implementation process and probably quarterly as implementation continues. These meetings would be open to the public.

The Steering Committee will continue to hold public meetings to provide opportunities for additional public outreach and communication.

The Steering Committee will continue to coordinate water management activities within the Basin to work cooperatively with stakeholders and interested parties to achieve the agreed-upon BMOs through the implementation of the Groundwater Management Activities. The GAC will also develop an outreach and educational program to engage other water interests in management of the Paso Robles Basin.

Historically, the water issues and efforts in the Basin have been discussed via a stakeholder – run "North County Water Forum." The District, County, and City have developed reports

regarding the Basin, as noted, utilizing the North County Water Forum (NCWF) as a stakeholder review group at significant milestones in the development of the reports. Similarly, the GAC, in implementing the Plan, can utilize the group of contacts associated with the NCWF to obtain feedback on deliverables and activities.

5.1.2 Agricultural Interests

In the Paso Robles Basin, no water districts or irrigation districts exist to provide water to agricultural water users because all agricultural water demands have been meet with groundwater pumped from landowner wells. While there are no agricultural water purveyors in the Basin, organized groups have formed to represent agricultural water interests in the Basin.

In 2006, vineyards make up approximately 85 percent of the agricultural acreage and 76 percent of the agricultural water demand. In the Paso Robles Basin, the Paso Robles Wine Country Alliance (PRWCA) and the Central Coast Vineyard Team (CCVT) are working to address vineyard-related water use issues.

Other crops, including row crops, olives, alfalfa, and row crops are also grown within the Paso Robles Basin, but may not have local industry-specific organizations to directly represent these interests, so non-vineyard, agricultural related groundwater management activities will be coordinated with the County Farm Bureau. As those groups become engaged, their representatives may become involved in the GAC.

5.1.2.1 Paso Robles Wine Country Alliance

The PRWCA actively promotes water use efficiency and sustainable practices. PRWCA recently formed the Wine Industry Water Committee (Water Committee), which is intended to '*… provide a broader coordination for inputs and feedback to our government partners in water evaluation, water quality, and water management planning.*' The Water Committee's role is to oversee, prioritize, and guide innovative, sustainable conservation efforts that promote and maintain a sound wine growing region; while preserving and protecting the long-term availability of water supply for all users. The Water Committee represents over 15,000 acres through its membership, and as part of the PRWCA, will encourage the implementation of voluntary, industry-accepted water management practices aimed at improving water use efficiency.

5.1.2.2 Central Coast Vineyard Team

The Central Coast Vineyard Team is a network of 300 local farmers that strive to protect the resources valuable to our farms and our communities by educating and guiding towards sustainable vineyard practices. The CCVT identifies and promotes the most environmentally safe, viticulturally and economically sustainable farming methods, while maintaining or improving quality and flavor of wine grapes. The CCVT looks to be a model for wine grape growers and will promote the public trust of stewardship for natural resources. Since 1996, the CVTT has helped growers conduct self assessments that address resource conservation, including water use efficiency best management practices.

5.1.3 Coordination with Agencies with Land Use Planning Responsibilities

Several of the management actions identified have clear policy requirements and implications. For example, effective protection of natural recharge areas will require coordination and communication with entities responsible for land use policies.

The development of consistent land use policies could be assisted by a regional groundwater forum such as the GAC. The purpose of this forum would be to foster coordination and cooperation among participating agencies to manage the Basin and to provide a framework for the formulation of Basin-wide projects and programs for the protection and use of groundwater resources.

For example, given the mutual concern of agencies within the Basin regarding the preservation of natural recharge areas and the protection of these areas from pollutants, local agencies could work through the forum to inform one another about land use practices that may contribute to groundwater degradation and the importance of reducing the occurrence of these land use practices. Some of these agencies with land use responsibilities in the Basin include:

- San Luis Obispo County Planning Department
- Monterey County Planning Department
- City of Paso Robles
- City of Atascadero
- State of California

Other issues may require coordination with additional local agencies.

5.1.4 Integration with Other Water Management Planning Efforts

This component addresses the need to integrate the Plan with other water–related efforts when making decisions to ensure multiple viewpoints are addressed. This requires coordination with individual local agencies, other regional planning efforts as well as Statewide planning efforts. The Plan is a living document that supports other planning efforts and in turn is also dependent upon other water management planning efforts that may occur in the Basin over time. The GAC and the Plan will need to be accessible to those efforts and Plan implementation should be coordinated with them. Some of these related water management efforts may include:

- Urban Water Management Plans
- Watershed Management Plans
- Integrated Regional Water Management Plans
- Water Master Plans
- General Plan Updates
- Resource Management System/Resource Capacity Study
- California Water Plan Update

5.2 Component 2 – Groundwater Monitoring and Data Collection

Improved groundwater monitoring and analysis and archiving of collected data are needed to implement several of the recommended management actions (e.g., conjunctive management and water quality management). The existing groundwater monitoring program is described in Section 3.3.1.

Additional monitoring is needed to fill several data gaps identified in the Plan. It is also recommended that the GAC utilize the existing County groundwater elevation database to facilitate the storage, retrieval, and archiving of groundwater data in the future.

5.2.1 Groundwater Elevation Monitoring

Groundwater elevation data is one of the primary sets of information available to the Groundwater Advisory Committee to understand the current groundwater conditions and longer term trends in groundwater elevations. To date, the District has used groundwater level data from the voluntary monitoring network to determine groundwater elevations in the Paso Robles Basin. Additional groundwater elevation data is needed to improve the understanding of the groundwater basin and support future management efforts such as updating the groundwater model.

The following actions could improve the groundwater monitoring and reporting program in the Paso Robles Basin. The recommendations are organized into improvements to the voluntary monitoring network, and development of a dedicated monitoring network. These are described in more detail in Appendix E.

5.2.1.1 Improvements to Voluntary Monitoring Network

Recommended steps needed to improve voluntary groundwater level monitoring network include:

- Increase the number of wells in groundwater level monitoring network in the Paso Robles Basin.
- Obtain well construction data for existing wells included in monitoring network to improve understanding of aquifer being represented by each well.
- Increase groundwater level monitoring frequency from semi-annual to quarterly. If this cannot be done for all wells in the monitoring network, it should at least be done for selected wells (such as the key BMO wells) that have construction information and a historical water level record.
- Expand the monitoring network to include areas experiencing changes in groundwater levels (see Figure 3-3) or changing land use conditions.

The GAC should assist the District with soliciting volunteers.

5.2.1.2 Development of a Dedicated Monitoring Network

The groundwater level monitoring network could be expanded by including dedicated monitoring wells to provide long-term continuity of the monitoring program and fill existing gaps in the monitoring network. The GAC should provide recommendations on the need for dedicated monitoring wells. Dedicated monitoring wells should be outfitted with transducers to record water level data at selected time intervals. This information should be downloaded routinely and included into annual reporting. This would provide additional information on the seasonal changes in water levels that are currently not captured in the spring and fall monitoring.

The dedicated monitoring well network could be expanded to include monitoring wells:

- In critical areas of concern where groundwater levels have declined or are experiencing groundwater level declines.
- In areas where there are data gaps either because there are no wells in the existing monitoring well network.
- At the edges of the developed land use in the Basin. These areas may not be experiences seasonal or long-term trends associated with localized pumping, so may be able to provide additional background water level data.

Some of the areas identified for dedicated monitoring network include:

- City of Paso Robles
- Creston Road Area
- Union Road Area
- Highway 46 west of Whitley Gardens
- Jardine Road Area
- Airport Road- Highway 101
- Highway 46 east of Whitley Gardens
- Creston Area
- Shandon Area
- Highway 41 south of Shandon
- North of San Miguel
- East of San Miguel

Some of the locations for additional monitoring are shown on Figure 5-1. Additional information is provided in Appendix E.

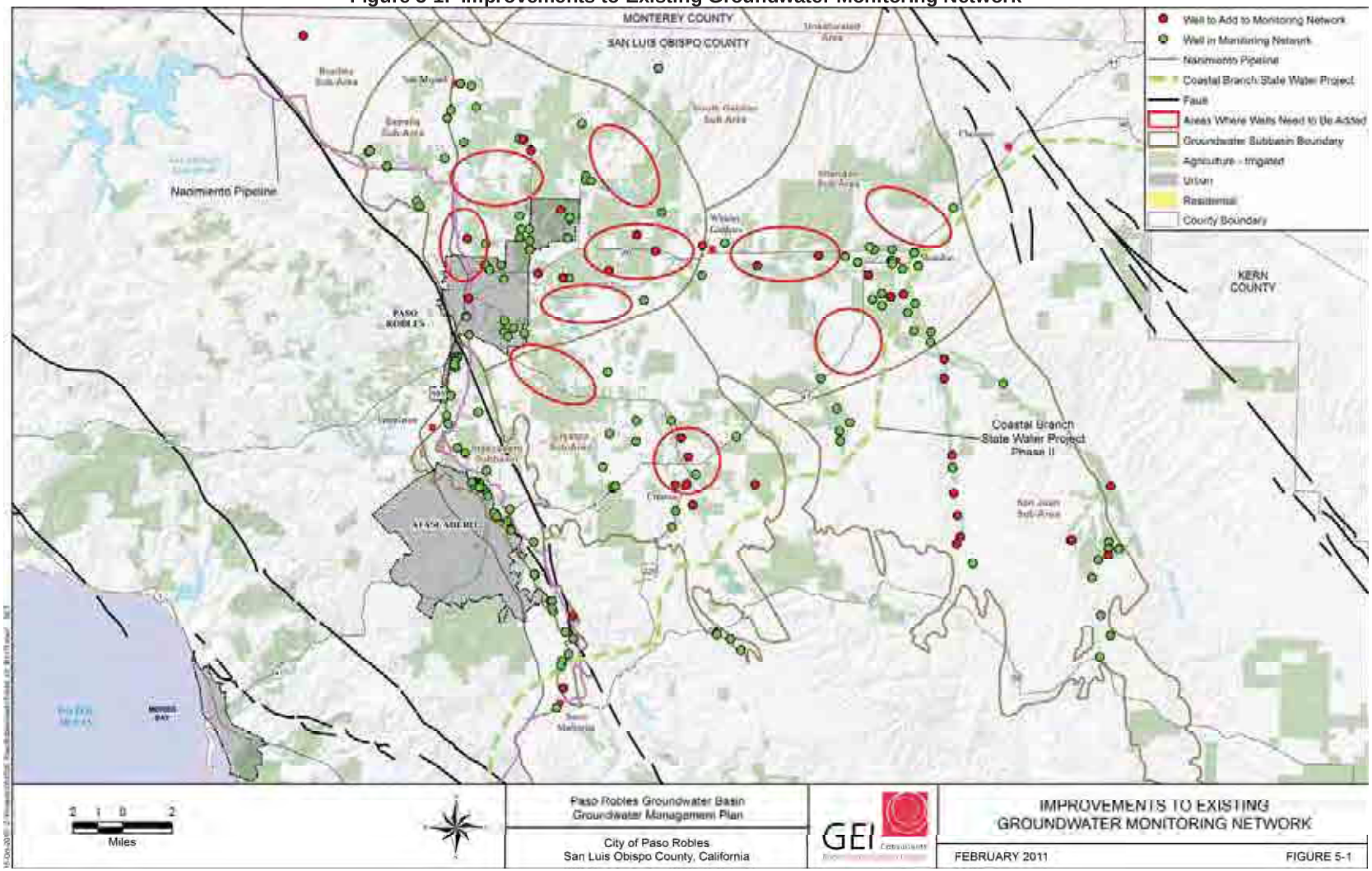
5.2.2 Groundwater Quality Monitoring

Many of the wells in the Paso Robles Basin are used for agricultural purposes. These wells are often monitored by well operators to ensure crop productivity. These monitoring records are typically kept private and are not public information. Water quality monitoring of drinking water sources has been performed by municipalities and private water purveyors in the Paso Robles Basin as required by the California Department of Public Health under Title 22, California Code of Regulations. Sources of water quality data include DWR, local

municipalities, USGS, and local growers. This information has been sufficient to develop an assessment of the general water quality conditions in the Basin necessary to support the existing land uses. Future conditions including land use changes may be served by expanding the water quality monitoring network to serve as a warning for changes in groundwater quality. Steps to improve groundwater quality monitoring network may include:

- Increase number of wells in groundwater quality monitoring network.
- Get well construction data for existing wells included in monitoring network to improve understanding of aquifer being represented by each well.
- Include groundwater quality considerations during the development of a dedicated groundwater monitoring network.
- Collect privately maintained water quality data from willing providers for purposes of project feasibility analysis. Confidentiality of the original data must be maintained.

Figure 5-1. Improvements to Existing Groundwater Monitoring Network



5.2.3 Inelastic Land Subsidence Monitoring

Because there has been no significant long-term land subsidence in the Basin there are no plans to develop a formal program to monitor and measure the rate of inelastic land surface subsidence within the Basin. The need for land subsidence monitoring will continue to be considered on an annual basis.

5.2.4 Data Management and Project Reporting Recommendations

Data management and project reporting are essential components of groundwater management. These efforts support all the monitoring activities described above, and involve communication with stakeholders and agencies. The data management and reporting activities associated with Plan implementation are described below.

5.2.4.1 County Groundwater Level Database

The County manages the groundwater level data it collects in a Microsoft Access database. The database contains approximately 159 wells that are monitored by the County or their cooperating partners within the Basin. Much of the information is considered confidential, so there are currently no plans to make the database accessible to the public.

As part of this Plan, a data management tool was developed to improve the capability of the existing database to extract specified data and display it in a report-ready format. This tool can be used in the future to generate individual well hydrographs or subarea hydrographs (as presented in Section 4).

5.2.4.2 County GIS Data

The District and the County collect water usage information and agricultural crop permit records and land use information that is in GIS format that could be accessed to support groundwater basin management efforts as needed.

5.2.4.3 Paso Robles Groundwater Basin Annual Report

Routine reporting of the conditions of the groundwater basin is an essential component of long-term groundwater management. Several reports have been prepared in the Basin documenting the groundwater conditions at a certain point in time. Part of this Plan is to development of an annual reporting framework that will facilitate consistent reporting on several aspects of groundwater management that are needed to make decisions on future groundwater management activities. The purpose of the Annual Report is to:

- Document the current conditions of the groundwater basin based on current data.
- Compare the current conditions to the established Basin Management Objectives.
- Evaluate the progress of the implementation of the Groundwater Management Activities identified in the Plan.

- Determine the effectiveness of the current management of the Basin at meeting the BMOs.
- Recommend the next steps to be undertaken to continue managing the groundwater resources of the Basin.

The 2009 Annual Report is included in Appendix E.

5.2.4.4 CASGEM Water Level Reporting Requirements

Future groundwater elevation monitoring and reporting will need to comply with the California Statewide Groundwater Elevations Monitoring Program (CASGEMs). This legislation, passed in 2009, is intended to establish a collaborative process between local monitoring parties and DWR to collect groundwater elevations statewide and make them available to the public.

To comply with CASGEMS:

- Local parties may assume responsibility for monitoring and reporting groundwater elevations.
- DWR will work cooperatively with local monitoring entities to achieve monitoring programs that demonstrate seasonal and long-term trends in groundwater elevations.
- A 'Monitoring Entity' is identified for each basin to coordinate monitoring in the basin and the reporting to DWR.
- Where a Monitoring Entity is not established, DWR will perform the monitoring functions. If local parties do not volunteer to perform the groundwater monitoring functions, DWR will assume those functions, and those parties will become ineligible for water grants and loans from the State.

The major deadlines for this effort include:

- On or before January 1, 2011: Parties seeking to assume groundwater level elevation monitoring functions must notify DWR. The District has notified DWR that they will be the monitoring entity for the Paso Robles Groundwater Basin.
- On or before January 1, 2012: Monitoring entities shall begin reporting seasonal groundwater elevation measurements.

5.3 Groundwater Resource Protection

The groundwater users of the Basin consider groundwater resource protection a critical component for ensuring its long-term sustainability. Groundwater resource protection includes basin recovery and sustainability as well as contamination prevention. Prevention measures include well construction, abandonment, and destruction policies, wellhead protection, and the monitoring and control of contaminated, poor quality, or saline water.

5.3.1 Well Construction, Abandonment, and Destruction Policies

Well construction and demolition standards are designed specifically to protect groundwater quality. Management actions to assist local agencies in complying with public health standards include the following components:

- Installation of sanitary well seals on all new wells in accordance with the California Well Standards.
- Installation of wells that conform to San Luis Obispo County and Monterey County standards include an impermeable seal between the upper and lower aquifers to prevent low quality water in the upper aquifer from entering the lower aquifer, where such low quality water exists.
- Abandonment of wells in accordance with the California Well Standards.

These management actions (currently enforced by California Department of Public Health and San Luis Obispo County and Monterey County) are particularly valuable in unincorporated areas not served by a water purveyor and could also apply to agricultural wells within the Basin in the future.

5.3.1.1 Implementation of Well Construction Policies

The San Luis Obispo County Environmental Health Services (in San Luis Obispo County) and Monterey Environmental Health Services (in Monterey County) administer the well permitting program within the Paso Robles Groundwater Basin. The well construction standards implemented by Environmental Health Services are consistent with those recommended in State Water Code Section 13801. This section of the State Water Code requires that counties, cities, and water agencies to adopt the State Model Well Ordinance as a minimum standard for well construction or a more rigorous standard if desired. The Environmental Health Services Departments have enacted well ordinances adopting the *California Well Standards, Bulletin 74-81*, and all supplements for the two counties. The Environmental Health Services staff also issue applications and review construction plans and specifications for wells drilled in the county and require and maintain well logs and water well driller reports for constructed wells.

The GAC will facilitate the following actions:

- Ensure that all member agencies are provided a copy of the applicable county well construction ordinance and that they understand the proper well construction procedures.
- Coordinate with member agencies to provide guidance, as appropriate, on well construction to prevent creating conduits through regionally confining beds.

5.3.1.2 Administration of Well Abandonment and Destruction Programs

It is believed that there may be many unknown, obsolete, or abandoned water supply wells within the Paso Robles Basin. These wells may provide potential conduits for contamination between aquifers or from saline water sources at depth.

One of the primary concerns of local agencies is the groundwater contamination risk posed by unused wells that have not been properly destroyed. Section 21 of DWR Bulletin 74-81 and revisions contained in Part II of Bulletin 74-90 allow classification of unused wells into two types: abandoned and inactive. An abandoned well is defined as one that has not been used for a period of one year and whose owner has declared the well will not be used again. If the well has not been used during the past year but the owner demonstrates his/her intention to use the well again for supplying water, the well is considered inactive. Four criteria must be met in order for a well to be maintained in inactive rather than abandoned classification. These criteria are:

- The well has no defects.
- The well is securely covered.
- The well is clearly marked.
- The surrounding area is kept clear of brush and debris.

Failure to meet these criteria could result in the well being classified as abandoned under current regulations. All abandoned wells, exploration, or test holes and monitoring wells must be destroyed as stated in Section 22 of Bulletin 74-81 and revisions contained in Bulletin 74-90.

An abandonment program should focus on those wells that pose the greatest threat to groundwater; however, numerous factors make the abandonment and destruction of wells difficult. These factors include lack of consistency in records regarding well construction, location, and use; cost of well destruction; and the defined classification for abandonment of wells. Well construction within the study area has taken place for nearly a century, with records and standards altered over time. Recent records pertinent to construction and location of new wells are more complete than earlier records that are often inconsistent. The lack of financial incentive for well owners to declare a well as abandoned also reduces the effectiveness of the well abandonment program.

The San Luis Obispo County Environmental Health Services and the Monterey County Environmental Health Services administers the well destruction program for those portions of the Paso Robles Groundwater Basin within their jurisdiction. The standards for construction are identified in the County code sand are based on State of California standards.

The GAC members, including San Luis Obispo and Monterey County, should facilitate the following actions for lands within their jurisdictions:

- Ensure that all GAC members and local agencies are provided a copy of the code and understand the proper destruction procedures and support implementation of these procedures.
- Follow up with local agencies and well owners on reported abandoned and destroyed wells to confirm information collected from DWR and receive information on abandoned and destroyed wells to fill gaps in county records.
- Obtain “wildcat” maps from California Division of Oil, Gas, and Geothermal Resources to ascertain the extent of historic gas well drilling operations in the area

because these wells could function as conduits of contamination if not properly destroyed.
- Seek funding to develop and implement a program to assist well owners in the proper destruction of abandoned wells.

5.3.2 Wellhead Protection Measures

The purpose of wellhead protection is to protect the groundwater used as a public supply, thereby reducing the costly treatment otherwise needed to meet relevant drinking water quality standards. A Wellhead Protection Area (WHPA), as defined by the Federal Wellhead Protection Program established by Section 1428 of the Safe Drinking Water Act Amendment of 1986, is "…the surface and subsurface area surrounding a water well or wellfield supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." The WHPA may also be the recharge area that provides the water to a well or wellfield. Unlike surface watersheds that can be easily determined from topography, WHPAs can vary in size and shape depending on subsurface geologic conditions, the direction of groundwater flow, pumping rates, and aquifer characteristics.

Identification of WHPAs is a component of the Drinking Water Source Assessment and Protection (DWSAP) Program administered by the California DPH. DPH set a goal for all water systems Statewide to complete Drinking Water Source Assessments by December 31, 2002. Table 5-2 identifies the water suppliers that have completed their required assessments by performing the three major components required by DPH listed below:

- Delineation of capture zones around sources (wells).
- Inventory of Potential Contamination Activities (PCAs) within protection areas.
- Vulnerability analysis to identify the PCAs to which the source is most vulnerable.

The GAC will facilitate the following actions:

- Request that member agencies provide vulnerability summaries from the DWSAP Program to be used for guiding management decisions in the basin.
- Contact groundwater basin managers in other areas of the State for technical advice, effective management practices, and "lessons learned," regarding establishing wellhead protection areas.

Table 5-2. Water Supplier DWSAP in the Paso Robles Groundwater Basin

System Number	System Name	Number of Sources
4000210	Creston's Country Store	1
4000649	Los Robles Mobile Home Estates	3
4000656	Santa Margarita KOA	2
4000693	Creston Elementary School	2
4000699	Paso Robles Truck Plaza, LLC	1
4000714	Santa Margarita Recreation Area	1
4000790	Paso Robles RV Ranch	1
4010002	Atascadero Mutual Water Co	18
4010003	San Miguelito MWC	3
4010006	Paso Robles Beach Water Assn	1
4010007	Paso Robles Water Department	15
4010010	San Miguel Community Services District	2
4010019	Templeton CSD	11
4010024	SLO CWWD No. 6-Santa Margarita	4
4010028	SLO CSA No. 16 -Shandon	2
4010080	Nacimiento Water Project	1
4010831	El Paso De Robles Youth Corr. Facility	3
4010832	Atascadero State Hospital	3
4010900	Caltrans -Shandon Rest Stop	1

5.3.3 Monitor Contaminated and Poor Quality Groundwater

The potential migration of poor quality groundwater is of concern to all groundwater users. Also of concern is any localized contamination of groundwater by point sources in the Basin.

While the GAC does not have authority or responsibility, it will coordinate with responsible parties and regulatory agencies to keep GAC members informed of the status of any groundwater contamination in the basin.

The GAC will facilitate the following:

- Coordinate with San Luis Obispo County and other groundwater users to continue the water quality data reporting program data for public supply wells and Basin characterization.
- If detections are found, facilitate meetings to inform groundwater users of the contamination and its potential spread. Specifically, the consideration of altering groundwater extraction patterns or altering production wells in the vicinity of areas of poor groundwater quality or pollutant plume to change the groundwater gradient.
- Provide a forum to share all information on mapped contaminant plumes and hazardous materials release sites. This mapping can be used to show where future monitoring wells should be located.
- Track upcoming regulations on septic systems, agricultural discharges, and other regulatory programs that pertain to water quality and inform groundwater users.

5.3.4 Control of Saline Intrusion

There are no known occurrences of saline water intrusion within the Basin. Although currently not a problem, there are hydraulic conditions such as depressed groundwater levels that could allow saline water intrusion to occur in the future from water at depth in the aquifer. If saline intrusion is identified by the monitoring program in the future, then an approach can be developed to address the problem.

The GAC will coordinate with member agencies to facilitate the following:

- Continue the existing groundwater quality monitoring in the Paso Robles Subbasin to identify occurrences of saline water.
- Observe total dissolved solids (TDS) concentrations in public supply wells that are routinely sampled under the DPH Title 22 Program for potentially increasing levels of salinity.

5.4 Groundwater Sustainability

To ensure a viable and sustainable groundwater resource, the Plan seeks to increase the amount of groundwater in storage in the Basin over the long term. This includes protecting natural recharge areas, supplementing natural recharge to better manage groundwater levels in the Basin.

5.4.1 Replenishment of High Quality Groundwater Extracted by Water Producers

An important component of groundwater management is the protection of major recharge and withdrawal zones. This strategy has far-reaching effects in the Paso Robles Groundwater Basin because rainfall infiltration provides much of the recharge to the Basin. To ensure an adequate supply of high quality groundwater, groundwater recharge must be adequate to replenish extracted groundwater.

Groundwater recharge from the surface occurs primarily from 1) infiltration and recharge of precipitation and 2) infiltration from streamflow. As shown on Figure 3-4, the soils of Basin have varying infiltration rates. Because infiltration of rainfall upon the ground surface is considered to be the primary source of recharge, the areas with the highest infiltration rates (greatest potential for recharge) should be preserved.

Planned urban development in the Paso Robles Basin may impact these natural recharge areas. These trends underscore the need to more precisely identify and map the remaining natural recharge areas and to use this mapping to protect important sources of recharge. The objective is to develop specific planning actions that offer varying degrees of protection, depending upon an area's significance as a source of recharge. Types of protection could include programs to educate public and planning entities about the importance of protecting recharge areas.

The first step in implementing this management action would be to identify recharge areas and develop a GIS-based analysis of natural recharge areas, to inform land use planning entities (San Luis Obispo County and cities of Paso Robles and Atascadero) of the importance of these areas and to make recommendations for their protection. Databases that are maintained by the Water Board and local land trust organizations may be helpful. Additional information such as groundwater levels in undeveloped portions of the basin and identification of near surface impediments to percolation of water is needed to support the identification and ultimate projection of recharge areas in the Basin.

A comprehensive approach to the protection and management of the major recharge and withdrawal zones is needed to preserve and protect recharge areas. The GAC supports the evaluation of the surface soils and surface geology within and directly adjacent to its boundary for the purpose of delineating areas having potentially high recharge rates. The GAC supports land use measures that will preserve potential recharge areas from development that would reduce or eliminate their effectiveness as recharge sites. These efforts will need to be coordinated with the San Luis Obispo County Planning Department and/or with other agencies associated with land use planning authority in the Basin.

The GAC member agencies will facilitate the following:

- Support the identification of areas having high potential for contributing to aquifer recharge and continue to communicate with land use planning entities to enact measures that will protect these lands from development that would reduce their value as recharge sites.
- Communicate with DWR and other governmental agencies studying groundwater and river interactions and infiltration potential.
- Collaborate with local land trust organizations (e.g., Land Conservancy of SLO County, California Rangeland Trust) and resource conservation agencies/organizations (e.g., Resource Conservation Districts, NRCS) to encourage protection of recharge areas.

5.4.2 Construction and Operation of Recharge, Storage, and Extraction Projects

All the groundwater users in the Basin including the District, cities, water providers, and agricultural interests share responsibility for the development and operation of recharge, storage, and extraction projects to provide long-term sustainability of the available groundwater resources.

The Paso *Robles Groundwater Banking Feasibility Study* completed in 2008 contains a feasibility-level evaluation of groundwater recharge and groundwater banking potential using a portion of the County's unused State Water Project allocation in the Paso Robles Basin using the existing available information and models. The feasibility study evaluated three locations for recharge or groundwater banking operations. Two of the three locations evaluated may provide opportunities for groundwater recharge/groundwater banking, but additional analysis would be needed to further refine the project yield and evaluate project costs, environmental and legal constraints and the impacts on overlying landowners. A significant portion of the costs for any of the alternatives evaluated construction of a new pipeline to convey the water from the Polonio Pass Water Treatment Plant to the recharge locations. The implementation timeframe for this project or similar projects is typically about 10 to 20 years.

To the extent feasible, the GAC may also support measures to coordinate development and optimize operation of facilities to improve the basin-wide effectiveness and efficiency of water management.

The GAC will facilitate the following:

- Encourage sharing of information on project planning, design, and operation among local agencies and private groundwater users.
- Promote a coordinated approach toward project development and operation to lower the costs and increase the benefits of water management efforts.
- Seek State and federal funding for projects and programs that will contribute to recharge of the groundwater basin, if determined to be feasible.
- Attempt to identify viable, cost effective projects that contribute to increased recharge within the Basin.
- Support update of the existing groundwater model that can be used to evaluate groundwater management opportunities, which may include groundwater recharge projects.

5.4.2.1 Imported Water Supplies

Imported water supplies may be available to water users in the Paso Robles Basin as described in Section 3 from the State Water Project (imported from outside of the County) and the Nacimiento Water Project (imported from outside the Basin, but within the County). The Nacimiento Water Project will provide a new supply of surface water to the Paso Robles Basin. When these supplies become available, they can be used to offset groundwater pumping and accommodate additional growth based on the use of surface water.

5.4.2.1.1 City of Paso Robles

The City of Paso Robles is a participant in the Nacimiento Water Project, with a current allocation of 4,000 AFY. A water rate increase was adopted by the City in 2010 that will take effect beginning January 2011. The rate increase will enable the design and construction of a 4 mgd capacity potable water treatment plant to move forward. The plant is currently under design and is scheduled for completion in 2013. The water treatment plant will enable the City to utilize its full Nacimiento Water Project water allocation and reduce groundwater pumping significantly from current levels. Use of this new supply is projected to have a beneficial effect on groundwater level decline rates in the Estrella sub-area and the basin as a whole.

5.4.2.1.2 City of Atascadero

The City of Atascadero is a participant in the Nacimiento Water Project, with a current allocation of 2,000 AFY. The water will be used to recharge the groundwater table in the vicinity of the current Salinas River underflow well fields so that it can be treated in the same manner as the rest of their groundwater supply.

5.4.2.1.3 Templeton CSD

The Templeton CSD is a participant in the Nacimiento Water Project, with a current allocation of 250 AFY. TCSD plans to receive raw water from the Nacimiento Water Project and is currently evaluating their plans to treat this water.

5.4.2.1.4 County Service Area No. 16

CSA 16 is located in the Shandon area and has the rights to 100 AFY from the State Water Project. Because of the high cost to develop this supply and the lack of need at the time, in 1995, the Board of Supervisors approved offering their 100 AFY allocation for sale to other entities in the County.

5.4.2.2 Recycled Water Potential in the Paso Robles Groundwater Basin

Currently, there is no direct use of treated wastewater in the basin. The cities of Atascadero and Paso Robles, and Templeton and San Miguel CSDs each operate wastewater treatment plants that discharge treated secondary effluent to the Salinas River using percolation ponds. However, direct use of recycled water for irrigation and indirect use for groundwater recharge could provide a significant quantity of water to offset current and future groundwater use within the basin.

The quantity of water available for potential recycled uses will increase as population increases. The amount of wastewater available for recycling is typically 40 to 50 percent of urban potable water deliveries on an annual basis. While some of this water is treated and contributes to basin return flows, much is now discharged from the basin to the north as Salinas River underflow.

Future direct and indirect use of recycled water within the Paso Robles basin can play a significant role in improved basin management. However, the primary impediment to implementation in the near-term is the high cost of upgrading treatment plant processes and the recycled water distribution system. Water quality concerns for recycled water users must also be addressed. Potential State and federal grant funding sources could help defray these costs, making these projects more feasible. It is recommended that the municipalities and service districts providing wastewater services pursue all potential county, State, and federal grant and loan sources to move these projects forward.

Table 5-3. 2009 Wastewater Discharges

	City of Paso Robles	City of Atascadero	Templeton CSD	San Miguel CSD
Year 2009	3,291	1,050	144	134
Average (1998 to 2009)	3,189	1,083	163	130
Minimum (1998 to 2009)	2,948	965	134	115
Maximum (1998 to 2009)	3.389	1,334	235	176

5.4.2.2.1 City of Paso Robles Water Recycling Plans

In 2000, the City of Paso Robles prepared a Comprehensive Recycled Water Study (Carollo, July 2000). The study assessed the existing wastewater treatment and disposal system and evaluated several alternatives for recycled water use. More recently, the City's Urban Water Management Plan (2005) and the Recycled Water Study Update (Boyle, 2006) identified alternatives for the reuse of treated wastewater. Four recycled water options were identified, including: 1) Groundwater recharge (requiring tertiary treatment and denitrification), 2) restricted irrigation (second effluent), 3) unrestricted irrigation (tertiary treatment), and 4) groundwater recharge (tertiary treatment and desalination).

The City of Paso Robles wastewater treatment plant currently produces secondary effluent with limited reuse potential. However, several thousand acre-feet of water of treated wastewater could be available for reuse if treatment capabilities at the Paso Robles Wastewater Treatment Plant are upgraded to include tertiary treatment and denitrification.

To prepare for future use of recycled water, Paso Robles is currently in the process of designing a wastewater treatment plant upgrade that will include denitrification in the first phase and the addition of tertiary treatment in the second phase. The project schedule calls for the Phase 1 plant upgrade to be completed in 2013, pending the approval of an increase in customer wastewater rates in 2011. The Phase I upgrade will set the stage for implementation of water recycling in the future. The Urban Water Management Plan 2005 identified 2025 as a target date for implementation of water recycling. The implementation of the Phase II upgrade and the construction of the first phase of a recycled water distribution system to deliver irrigation water to Barney Schwartz Park, local golf courses, and new development will depend on available funding. Paso Robles plans to complete a water

recycling master plan in 2010/11 that will identify potential direct users, groundwater recharge sites, pipeline routes, and project cost estimates.

5.4.2.2.2 Templeton CSD Water Recycling Plans

In addition, the Templeton CSD may be making future provisions to expand and divert additional wastewater flows (which currently flow to the City of Paso Robles WWTP) in order to recycle additional treated effluent into the Salinas River underflow via percolation ponds, increasing available water for extraction.

5.4.3 Management of Sustained Groundwater Levels

While the Basin is experiencing declining groundwater levels over a significant area of the Basin, it has not been identified to be in a state of overdraft. The GAC will continue to facilitate actions to support groundwater levels in the Basin, which include:

- Continue to support existing groundwater elevation monitoring and reporting programs in the Basin.
- Support efforts to expand the voluntary groundwater monitoring network while at the same time pursuing the development of a dedicated groundwater monitoring network to supplement the existing network.
- Encourage the implementation of water conservation programs in all water use sectors (agricultural, municipal, small commercial, small community, and rural residential) to reduce groundwater pumping.
- Seek funding for programs and projects that would improve groundwater conditions in the Basin.
- Support programs that reduce groundwater pumping through substitution of surface water or recycled water for groundwater.
- Be aware of the impact of potential changing land use conditions on groundwater resources in the Basin.
- Identify other opportunities to reduce water demand such as rainwater harvesting and storm water capture for groundwater recharge.

5.4.4 Modeling and Technical Analysis

The original groundwater model developed for the Paso Robles Basin has been used to support several different groundwater related projects including establishing an initial perennial yield estimate and evaluating the effects of groundwater recharge and banking alternatives. The recent peer review of the model and other technical analyses completed in the basin has lead to the recommendation that the model should be updated in the next three to five years.

A model update framework needs to be developed to guide the update process that identifies the specific issues to be addressed by the model, appropriate approaches, and data sets necessary to support the model update. The GAC will support the ongoing technical analysis undertaken in the Basin and the steps necessary to update the groundwater model, which may include:

- Developing modeling goals and objectives for the model update to identify:
    - What questions do we want the model to answer?
    - What methods or approaches should be used to calculate soil moisture budgets, water budgets, and change in storage?
- Identifying the data sets that need to be developed or improved to support model development, which may include:
    - Groundwater level data
    - Groundwater pumping data
    - Agricultural demand data (including irrigated acreages, irrigation methods and implementation of BMPs)
    - Hydrogeologic data
    - Surface water and groundwater level data to improve understanding of the surface-groundwater interaction at selected locations across the basin
    - Developing other data sets as needed to support specific analyses

5.5 Water Demand Management and Conservation

Water demand management and water conservation provides the primary management activities to reduce groundwater pumping in the Paso Robles Basin and influence groundwater level declines. Water conservation opportunities apply to all water use categories. Water demand and conservation are organized below by water use category for the agricultural, urban, and rural residential water use categories.

5.5.1 Agricultural Water Demand Management and Conservation

5.5.1.1 Statewide Agricultural Water Management Requirements

Agricultural water management in California is addressed at the State, County, and local levels, and includes input from industry organizations such as the Agricultural Water Management Council. The State of California recently passed the Water Conservation Act of 2009 as part of SBx7-7. SBx7-7 includes two provisions related to agricultural water management. The first provision includes water conservation, measurement, and reporting activities for agricultural water suppliers. This provision focuses on the measurement of the volume of water delivered to customers and adopting a pricing structure based at least in part on the quantity of water delivered. In this legislation, a ‘customer’ is defined as “a *purchaser of water from a water supplier who uses water for agricultural purposes.*”

There are currently no agricultural water suppliers in the Paso Robles Groundwater Basin, so this provision does not apply within the Paso Robles Groundwater Management Plan Area.

SBx7-7 also includes provisions for DWR along with the Agricultural Water Management Council, academic experts, and other stakeholders to develop a methodology for quantifying the efficiency of agricultural water use. DWR is required to report back to the Legislature on or before December 31, 2011 on the proposed methodology and plan for implementation.

There is currently no requirement for implementation of the methodology in the State. While neither of these provisions currently apply to agricultural water management in the Basin, the intent of these activities should be considered while developing an agricultural water management strategy and appropriate water management actions in the Paso Robles Basin.

5.5.1.2 GMP Coordination with the Local Agricultural Interests

The following potential activities have been identified by PRWCA and other stakeholders to facilitate coordination between the Plan implementation, the PRWCA Water Committee, the CCVT and other agricultural groups. Those activities that were identified by PRWCA as potential actions they favor are indicated by "(PRWCA)" following the action. The Plan encourages that the following actions be reviewed and implemented as appropriate by the PRWCA, CCVT, other agricultural groups, and other stakeholders.

Near-term Actions (next three years)

- Identify and disseminate vineyard and winery Best Management Practices (BMPs) in the Paso Robles Basin based on industry accepted standards. (PRWCA)
- Continue programs that educate and encourage the advantages to conduct self audits to optimize water use efficiency and water budgeting through a business plan perspective. (PRWCA)
- Conduct regular outreach activities within PRWCA and CCVT membership and other vineyards and other ag commodities in the Basin to further the implementation of BMPs. (PRWCA)
- Coordinate with the County to conduct an outreach program to encourage growers to voluntarily make wells available to the County's groundwater level monitoring program in the Basin. (PRWCA)
- Participate in the UC Extension Irrigation Study, which is scheduled for completion in 2012. (PRWCA)
- Develop an approach to benchmark estimate water savings from future BMP implementation. (PRWCA)
- Develop a report that identifies vineyard Best Management Practices (BMPs) in the Paso Robles basin, based on industry-accepted standards. The report would also provide data on the number of acres of vineyards that have implemented various BMPs.
- Develop a report that identifies BMPs for other agricultural commodities in the Basin.
- Establish a methodology to estimate the volume of additional water that can be conserved through additional BMP implementation among growers.

Long-term Actions (beyond three years)

- Continue to support BMP implementation.
- Continue to support groundwater level monitoring activities in the Basin.

- Continue to encourage participation in BMP implementation programs and groundwater level monitoring activities.

5.5.2 Urban Water Demand Management and Conservation

5.5.2.1 City of Paso Robles

From 1999 to 2008, total annual per capita water use within the City of Paso Robles (based on total water pumped) average was 241 gallons per capita per day (gpcd). In 2009, the City established a Water Conservation Manager position, implemented mandatory outdoor watering use restrictions and began the process of implementing comprehensive, long-range water conservation programs. The immediate goal of the watering restrictions was to reduce peak summer demand by 20 percent to alleviate water production shortage cause by lowering water levels in City wells. The restrictions have been successful the last two summers and will be continued until the Nacimiento WTP is on-line. The long-term objectives of ongoing conservation programs are: 1) Meet the California Senate Bill 7 mandate of achieving a 20 percent reduction in per capita use by the year 2020 (approximately 193 gpcd), and 2) implement the comprehensive list of Municipal Best Management Practices programs outlined in the California Urban Water Conservation Coalition Memorandum of Understanding.

In 2008/09, the City of Paso Robles implemented a comprehensive water conservation program that included the following:

- Toilet replacement rebates.
- Turf replacement rebates for conversion to drought-tolerant landscaping.
- Home water surveys (audits).
- Large turf area audits and commercial/industrial water surveys (CII).
- Workshops on low-water-use landscaping.
- Conservation outreach and education programs (includes radio and print media advertising, brochures, direct mail, bill stuffers, bill messages, signage, event sponsorship and participation).
- School Education programs in the Paso Robles Schools.
- Conservation website development.
- Passage of a Water Efficient Landscape Ordinance that limits the amount of turf in new residential and commercial development, and prohibits turf in new public road rights-of-way. The ordinance also includes new efficient irrigation design standards.
- Continued enforcement of summer watering restrictions (3-day watering schedule).

Additional programs that may be considered for implementation in the future include:

- Rebates for High Efficiency Clothes Washers.
- CII customer incentive programs (rebates) for conservation technology investments.

The combined effect of Paso Robles' water conservation programs and the conservation impact of planned water rate increases is projected to achieve an estimated 20 percent reduction in overall per capita water use, compared to historical water use rates prior to mandatory summer water use restrictions.

5.5.2.2 Atascadero Mutual Water Company

Atascadero Mutual Water Company is a member of the California Urban Water Conservation Council, Groundwater Guardian Program, Alliance for Water Efficiency, Water Education Foundation, and SLO County Partners in Water Conservation.

5.5.2.3 Templeton Community Services District

The Templeton Community Service District (TCSD) currently promotes water conservation throughout the TSCD service area. The District has a full-time water conservation coordinator who works to educate the public through informational workshops, literature, handouts, and occasional rebate programs. Recently, the TCSD has revised their Water Conservation Ordinance to ensure that conservation standards for the TCSD remain current and effective. The TCSD is an active member in the SLO County Partners in Water Conservation, Central Coast Partners in Water Quality, and the California Urban Water Conservation Council.

5.5.3 Rural Residential Demand Management and Conservation

Rural residential areas are located throughout the valley floor portion of the Paso Robles Basin, and rely on groundwater to meet their water needs. Increased groundwater use in and around these areas has added to the regional decline in groundwater levels over time. Because some rural residential users rely on relatively shallow individual wells, drawdown in pumping wells as the basin overall has declined has resulted in groundwater levels dropping below the bottom of their wells.

A conservation program is needed to reduce water use and improve efficiency among rural residential water users. Such a program could include components to reduce indoor and outdoor water use. Some components for Rural Residential demand management and water conservation program could include:

- Development of a water conservation incentive program for rural residential water users.
- Development of water education and outreach materials for rural residential water users.
- Development and dissemination of landscape planning materials that encourage conservation and increase or promote storm water capture and recharge. These efforts could be coordinated with the identification of soil infiltration rates to encourage local groundwater recharge.
- Development of programs that increase water reuse opportunities such as:
    - Rainwater harvesting

- Greywater use
- Water recycling

The likely entity to conduct a conservation program for rural residential users is the County. Partnering with other organizations (cities and CSDs with programs already in place, the RCD, NRCS, Ag Commissioner, etc.) and seeking grants will help with staffing and financial resources.

6 Stakeholder Involvement

The City of Paso Robles along with the San Luis Obispo County Flood Control and Water Conservation District lead the preparation of the Paso Robles Regional Groundwater Management Plan. This plan was developed to comply with provisions of the Groundwater Management Planning Act of 2002, including provisions related to public involvement processes. Some of the components of the stakeholder involvement process are described below.

6.1 Groundwater Advisory Committee

A Groundwater Advisory Committee was formed to discuss the groundwater management issues of the Basin and guide the planning process to develop the Plan. The GAC was formed from interested parties and stakeholder, many of whom had participated in previous groundwater-related efforts as part of the North County Water Forum. Through detailed discussions, the GAC with input from stakeholders and interested parties representing the seven subareas of the Basin developed the initial BMOs and related implementation plan. The GMP is the result of an approximately two-year effort, including, a six-month suspension of the project from February 2009 until November 2009 because of grant funding issues.

6.2 Public Involvement

An extensive public involvement process was included in the efforts to develop the GMP. Some of the components of the public involvement process include the following:

The initial mailing list included over 40 contacts. A flyer (included in Appendix C) announcing the preparation of the groundwater management plan was sent to each person on the contact list. Emails were also sent to each email address with an electronic version of the flyer attached.

During the completion of the Paso Robles Groundwater Basin Water Banking Feasibility Study in 2007, and during grant application preparation process (to prepare the Plan), the City of Paso Robles and the District notified stakeholders for their intent to prepare a groundwater management plan.

6.2.1 GAC Communications

Communications regarding the GAC meetings and the opportunity to participate in the GMP development were distributed electronically via the email distribution list, and by posting information on the County's and the City's websites along with other Paso Robles Groundwater Basin information.

During the project, draft deliverables, meeting notices, and briefings were distributed electronically via email. Project deliverables and presentations were also posted on the County's website.

GAC members and stakeholders provided comments to the County and/or City by email or by mail or phone conversation.

6.2.2 GAC Meetings and Workshops

- GAC No. 1 - January 15, 2009: This was the project kickoff meeting. Goals for this meeting included:
  - Provide project overview and approach
  - Describe project schedule and coordination activities
  - Identify the GAC members (listed on Table 6-1 below)

Table 6-1. GAC Members and Subarea Representatives

Name	Affiliation	Subarea
Jay Short	Templeton CSD	Atascadero
John Neil	Atascadero Mutual Water Co.	Atascadero
Sue Luft	WRAC	Creston
Duane Picanco	Paso Robles City	Creston Estrella
Dave & Debra Compton	Private	Estrella
Ray Allen	SLO Co Cattlemen	Estrella
Robert Johnson	Monterey County Water Resources Agency	North Gabilan Bradley
Steve Sinton	PRIOR	San Juan
Willy Cunha	Sunview Shandon	San Juan
Dennis Bowman	Green River MWC	Shandon
Mike Kelley	Green River MWC	Shandon
Mike Steinboer	Green River MWC	Shandon
Randy Diffenbaugh	Shandon Advisory Committee	Shandon
Bob Roos	North County Water Forum	
Joy Fitzhugh	SLO Co Farm Bureau	

Additional GAC meetings were held on the dates listed below. The attendance lists and presentation materials for each meeting and workshop are included in Appendix G.

- GAC No. 2 – November 12, 2009
- GAC No. 3 – February 25, 2010
- BMO Workshop No. 1 – April 19, 2010
- BMO Workshop No. 2 – May 10, 2010
- BMO Workshop No. 3 – May 10, 2010
- GAC No. 4 – August 2, 2010
- GAC No. 5 – December 2, 2010
- GAC No. 6 – February 10, 2011

The Basin Management Objective Workshops were held in April and May 2010 with the different subareas to support their development of groundwater Basin Management Objectives.

The GAC meetings and workshops generally coincided with project deliverables to get review and comment from the GAC during the development of the Plan. Draft materials were generally made available ahead of the meetings, and reviewed at the GAC meetings to identify and address any questions related to the draft materials. Each GAC member, stakeholder, and interested parties were provided the opportunity to review and comment on the draft materials. Comments were provided to the County or City, and forwarded to the project team for incorporation into the Plan.

6.2.3 Involvement of Other Agencies and Entities

The preparation of the GMP was coordinated by the City of Paso Robles and the District, and included participation from a wide variety of stakeholders and local agencies that represented interests in the Paso Robles Basin. Throughout the planning process, all the entities, stakeholders, and interested parties were invited and encouraged to participate in developing the Plan. The sign-in lists from the GAC meetings and workshops include over 40 different entities that represent the different water user groups in the basin. Additionally, the City of Paso Robles and the District met several times with representatives of the PRWCA/CCVT to discuss agricultural water conservation opportunities.

6.2.4 Coordination with Other Agencies

The GAC has coordinated the planning process with other neighboring water agencies and subbasins. Monterey County Water Resources Agency is a member of the GAC for the Paso Robles Basin GMP, and also represents Monterey County interests and coordinates with activities associated with the Salinas Valley Groundwater Basin and Nacimiento Reservoir. The GMP has also coordinated within San Luis Obispo County through the San Luis Obispo County Integrated Regional Water Management Plan and the San Luis Obispo County Master Water Plan. Draft copies of the GMP were provided to these agencies.

6.2.5 Public Involvement

The GAC will continue to coordinate water management activities within the basin and to work cooperatively for implementation of the BMOs outlined in this Plan. The GAC will also develop an outreach and educational program to engage other water interests in water management within the Basin.

The GAC will continue to work with the PRWCA/CVVT and other agricultural groups to improve data collection efforts in the Basin and coordinate groundwater management efforts.

6.2.6 Developing Relationships with State and Federal Agencies

Over the last several years, the water interests in the Paso Robles Basin have been working with a variety of State and federal agencies including:

- University of California Extension to assess vineyard irrigation practices and water usage.
- United States Geological Survey to investigate land subsidence.
- Natural Resources Conservation Service, through their participation in numerous groundwater projects.
- California Department of Water Resources:
    - Investigated groundwater banking feasibility in the Paso Robles Basin (grant funded project)
    - Preparation of an Integrated Regional Water Management Plan for San Luis Obispo County

Additional coordination is expected with the Central Coast Regional Water Quality Control Board due to anticipated changes to the Agricultural Waiver Program and salt nutrient management planning.

6.2.7 Dispute Resolution Process

The groundwater users in the Paso Robles Basin have used the following approaches to resolve issues in the Basin which demonstrate their ability to work together:

- North County Water Forum has served forum for discussion of water related issues in the Paso Robles Basin over the last ten years during many of the projects identified in Section 1 of the Plan. The GAC is an extension of this group, and will continue to provide a forum for discussion and early resolution of groundwater issues in the Basin.
- The Water Resources Advisory Committee has been used as a venue to address water management issues affecting San Luis Obispo County, including the Paso Robles Basin.
- The Paso Robles Groundwater Basin Agreement was developed in 2005 in response to groundwater rights issues among the Landowners and Municipal Users in the Basin. The Agreement stated that the Basin was not in a state of overdraft at that time, and outlined the procedures for determining the Basin is in a condition of overdraft.

The dispute resolution process will be formalized as part of the Basin governance during the implementation of the Plan.

7 Plan Implementation

This section includes a discussion of the approach, schedule, and funding information to support the implementation of the Plan.

The County of San Luis Obispo (County), including the San Luis Obispo County Flood Control and Water Conservation District is the local agency with the authority to lead Plan implementation. The lead agency will coordinate with the other ongoing efforts in the Basin and their respective lead agencies.

7.1 Implementation of Groundwater Management Activities

This section of the implementation plan identifies the specific Groundwater Management Activities and the lead parties responsible for their implementation. The GMAs presented on Table 7-1 are organized by the Groundwater Components described in Section 5. Each GMA includes its relative implementation priority and status, approximate schedule for implementation, and the lead parties responsible for its implementation, including the identification of a lead agency. It should be emphasized that all actions and participation of agencies and stakeholders is voluntary in nature, and subject to annual budgeting approvals.

It should be noted that several County departments are currently involved in work efforts associated with this Plan, including Public Works, Planning and Building, Public Health, and the Agricultural Commissioner's Office. Determining the specific roles and support of Plan efforts by those departments is also an implementation recommendation, and will be considered in annual budgeting and other decisions.

Table 7-1
Summary of Plan Implementation Progress

Component Category	Priority/ Status	Implementation Schedule			Stakeholder and Agency Participation				
		Reoccurring (Annual)	Within Three-Years	Beyond Three Years	Steering Committee	County	Urban Water Purveyors	Agriculture	Rural Residential
Component Category 1: Stakeholder Involvement and Coordination									
1.1 Involvement with Stakeholders and Public									
1. Provide public briefings at meetings (WRAC, Board Meetings, Other) and GMP annual meetings regarding GMP implementation progress.	High - Ongoing	X			Facilitate				
2. Work with private groundwater users and local water purveyors to maximize outreach on GMP activities.	High - Ongoing	X			Facilitate				
1.2 Formation of a Groundwater Advisory Committee for GMP Development and Implementation									
1. Invite local agencies that are managing groundwater, local advisory committees, and private well owners to participate on GAC through Steering Committee	Completed	X			Facilitate				
2. Develop a semi-annual GAC meeting schedule to report on the state of the Basin and address ongoing issues. These meetings may be incorporated into ongoing projects in the Basin as appropriate.	High	X			Facilitate				
3. Develop a formal mechanism for ongoing implementation of this GMP that includes a Steering Committee and Technical Advisory Committee	High	X			Facilitate				
1.3 Coordination with Other Agencies									
1. Coordinate with agencies with land use planning authority to coordinate land use planning regulations with groundwater management activities.	Ongoing	X			Facilitate	X	City Paso Robles City of Atascadero		
2. Coordinate implementation of the recommendations of the Paso Robles Groundwater Basin Resources Capacity Study	Medium		X		Facilitate	X			
1.4 Integration with Other Water Management Planning Efforts									
1. Integrate with San Luis Obispo County IRWMP Efforts.	Completed - Ongoing	X			Facilitate	X			
2. Integrate with San Luis Obispo County Master Water Plan.	Ongoing				Facilitate	X			
Component Category 2: Groundwater Monitoring and Data Collection									
2.1 Groundwater Elevation Monitoring									
1. Coordinate with local purveyors, San Luis Obispo County, DWR, and other basin groundwater extractors to identify additional appropriate wells for monitoring in addition to the County's water level monitoring.	High - Ongoing	X			Facilitate	X	All water purveyors	PRWCA & Other Growers	Individual Residents
2. Coordinate with local purveyors, San Luis Obispo County, DWR, and other basin groundwater extractors to ensure that the selected wells are maintained as part of a long-term monitoring network.	High - Ongoing	X				X	All water purveyors	PRWCA & Other Growers	Individual Residents
3. Coordinate with local agencies, DWR, and other basin groundwater extractors to ensure that needed water level data are collected, verify that uniform data collection protocols are used among agencies, and confirm that data sharing and archiving procedures are implemented.	High - Ongoing	X				X	All water purveyors	PRWCA & Other Growers	Individual Residents
4. Consider ways to fill gaps in the monitoring well network by identifying additional suitable existing wells or identifying opportunities for constructing new monitoring wells.	High - Ongoing	X			Facilitate	X			
5. Annually assess groundwater storage and elevation trends and conditions based on the network. Compare current trends to historical trends. Present findings to DWR and coordinate on future program modifications.	High	X			Facilitate	X			
6. Establish District as Monitoring Entity in California Statewide Groundwater Elevation Monitoring Program. Submit groundwater elevation data to DWR annually.	High - Immediate	X				X			
7. Assess the adequacy of the groundwater storage and elevation monitoring well networks annually.	High - Ongoing	X			Facilitate	X			
2.2 Groundwater Quality Monitoring									
1. Coordinate with County to ensure that the selected wells are maintained as part of a long-term monitoring network.	High	X				X	All Water Purveyors		
2. Consider ways to fill gaps in the monitoring well network by identifying additional suitable existing wells or identifying opportunities for constructing new monitoring wells.	Medium	X			Facilitate	X	All Water Purveyors		
3. Coordinate with County, other basin groundwater extractors, and other local, State, and federal agencies to identify where wells may exist in areas with sparse groundwater quality data. Identify opportunities for collecting and analyzing water quality samples from those wells. If wells are sampled through other programs, coordinate with the appropriate agency on sharing of data.	Medium	X				X	All Water Purveyors		

Table 7-1
Summary of Plan Implementation Progress

Component Category	Priority/ Status	Implementation Schedule			Stakeholder and Agency Participation				
		Reoccurring (Annual)	Within Three-Years	Beyond Three Years	Steering Committee	County	Urban Water Purveyors	Agriculture	Rural Residential
4. Assess Current groundwater trends in comparison to historical trends. Present findings to DWR and coordinate on future program modifications.	Medium	X				X	All Water Purveyors		
5. Assess the adequacy of the groundwater quality monitoring well network annually.	Medium	X				X	All Water Purveyors		
2.3 Inelastic Land Subsidence Monitoring									
1. Coordinate with DWR on the necessity of developing and implementing a monitoring program.	Low			X		X	All Water Purveyors		
2. Explore funding opportunities for the installation of subsidence extensometers and other benchmarks to perform periodic repeat-level surveys at the benchmarks if a monitoring program is determined to be warranted.	Low			X		X			
3. Educate local agencies on the potential for land surface subsidence and signs that could be indicators of subsidence.	Low			X		X			
2.4 Data Management System									
1. Continue to coordinate with County and other water purveyors to determine what types of data are currently available and in what formats.	High - Ongoing	X				X			
2. Incorporate recommendations from County's Data Enhancement Plan to improve data management storage, analysis, and dissemination.	High	X				X			
3. Develop data management methods on an "as needed" basis for data determined critical to the management of water resources in the Basin.	Medium	X				X			
2.5 Project Reporting									
1. Reporting groundwater levels to DWR as part of CASGEMs Program	High	X				SLOC FCWCD			
2. Establish Annual Monitoring Report Format to support annual reporting in the Basin	Completed	X				SLOC FCWCD			
3. Develop implementation reporting format to communicate GMP progress to stakeholders and interested parties.	High	X			Facilitate	SLOC FCWCD			
Component Category 3: Groundwater Resource Protection									
3.1 Well Construction, Abandonment and Destruction Policies									
1. Schedule a meeting with the County Department of Public Health, interested M&I water purveyors, and private well owners to facilitate the exchange of information of existing County well ordinances and discuss possible new ordinances.	High	X			Facilitate	X	X	X	X
2. Request copies of the most recent delineated investigation borders for remediation sites or other known groundwater contaminant sources to; County, M&I water purveyors, and private well owners within the Basin for their review and possible use.	Medium		X		Facilitate	X	X	X	X
3. Provide support to local agencies and private well owners on well construction, destruction, and abandonment as requested. For example, providing access to existing analysis on subsurface hydrogeology for the construction of new wells.	Medium	X			Facilitate	X	X	X	X
4. Obtain "wildcat" well map from California Division of Oil and Gas to ascertain the extent of historical gas well drilling operations in the area as these wells could function as conduits of contamination if not properly destroyed.	Low		X		Facilitate	X			
3.2 Wellhead Protection Measures									
1. Request that municipalities provide vulnerability summaries from the DWSAP to the GAC to be used for guiding management decisions in the basin.	Medium				Facilitate	X	X		
3.3 Monitor Contaminated and Poor Quality Groundwater									
1. Request information from the RWQCB and other responsible agencies with regard to water quality concerns within the basin.	Low		X			X			
2. Provide local agencies with all information obtained from OES and the RWQCB on the extent of the investigation areas of contaminant plumes and contaminated sites for their information in developing groundwater extraction patterns and in the siting of future production or monitoring wells.	Low		X			X			
3.4 Control of Saline Water Intrusion									
1. Request information from the RWQCB and other responsible agencies with regard to water quality concerns within Basin.	Medium			X		X			
2. Acquire geophysical logs for oil and gas exploration borings. These logs are available through the State of Department of Conservation Division of Oil and Gas. These electrical geophysical logs will delineate the base of freshwater at each boring location.	Low			X		X			

Table 7-1
Summary of Plan Implementation Progress

Component Category	Priority/ Status	Implementation Schedule			Stakeholder and Agency Participation				
		Reoccurring (Annual)	Within Three-Years	Beyond Three Years	Steering Committee	County	Urban Water Purveyors	Agriculture	Rural Residential
3. Publish information on salinity trends in annual basin report.	Low			X		X			
Component Category 4: Groundwater Sustainability									
4.1 Replenishment of High Quality Groundwater Extracted by Water Producers									
1. Complete analysis of groundwater recharge areas in Basin	Medium		X			X			
2. Collaborate with other resource organizations to encourage protection of recharge areas.	Medium		X		Facilitate	X		Resource Conservation Districts, Land Trust Organizations	
3. Continue pursuing the projects to deliver Nacimiento Water Project within the Paso Robles Groundwater Basin	High		X			X			
4.2 Construction and Operation of Recharge, Storage, and Extraction Projects									
1. Refine instituional, economic, and environmental analysis at locations identified for groundwater banking	Low			X		X			
4.3 Additional Groundwater Management Opportunities									
1. Identify potential storm water recharge opportunities in the Basin	Medium		X			X	City of Paso Robles City of Atascadero		
4.4 Modeling and Technical Analysis									
1. Develop modeling goals and objectives to guide model update	High		X		Facilitate	X			
2. Identify additional technical analyses necessary to support model update	High		X			X			
3. Collect data needed to support technical analyses and model update.	High	X				X			
4. Complete technical analysis necessary to support future groundwater model update	High	X				X			
5. Complete groundwater model update	High			X		X			
6. Meet with County and local agencies that may experience surface water and groundwater interaction to understand the importance of issues, and the need for future studies.	Medium		X			X			
7. Develop program to understand groundwater surface water interaction along the Salinas River.	Medium			X		X			
8. Coordinate with DWR on the development of uniform data collection protocols and data sharing and archiving procedures.	High	X				X			
Component Category 5: Water Management									
5.1 Agricultural Water Management Practices									
1. Coordinate groundwater management activities with Paso Robles Wine Country Alliance Water Committee (Semi-Annual Meetings) with GAC	High	semi-annual			Facilitate	X		PRWCA/ CCVT	
2. Complete UC Extension study on vineyard irrigation practices and disseminate results to stakeholders	High		X			X		PRWCA/ CCVT	
3. Develop and disseminate to area growers vineyard irrigation BMPs	High		X		Facilitate	X		PRWCA/ CCVT	
4. Develop and disseminate to area growers, agricultural (non-vineyard) irrigation BMPs	High		X		Facilitate	X		PRWCA, CCVT, Farm Bureau, RCD's	
5. Evaluate effectiveness of BMPs outreach programs	High	X			Facilitate	X		PRWCA, CCVT, Farm Bureau, RCD's	
6. Identify water conservation measures for wine making operations. Prepare and disseminate outreach materials.	High	X			Facilitate	X		PRWCA/ CCVT	

Table 7-1
Summary of Plan Implementation Progress

Component Category	Priority/ Status	Implementation Schedule			Stakeholder and Agency Participation				
		Reoccurring (Annual)	Within Three-Years	Beyond Three Years	Steering Committee	County	Urban Water Purveyors	Agriculture	Rural Residential
7. Develop winery water use efficiency materials and landscape BMP's	Medium		X		Facilitate	X		PRWCA/ CCVT	
8. Make available water use efficiency outreach materials for non-PRCWA vineyards and wineries.	High - Ongoing	X			Facilitate	X		PRWCA/ CCVT	
9. Develop and disseminate region-specific BMPs that support long-term vineyard and winery water sustainability.	High - Ongoing	X			Facilitate	X		PRWCA/ CCVT	
10. Develop outreach program to encourage growers to participate in County's voluntary groundwater level monitoring program.	High - Ongoing	X			Facilitate	X		PRWCA/ CCVT Farm Bureau	
11. Support outreach and communication of groundwater management planning activities to growers.	High - Ongoing	X			Facilitate	X		PRWCA/ CCVT Farm Bureau	
12. Identify well owners located in gaps in the existing voluntary groundwater level monitoring network.	High - Ongoing	X			Facilitate	X		PRWCA/ CCVT Farm Bureau	
13. Develop water conservation BMPs for non-viticulture agriculture.	Medium				Facilitate	X		PRWCA/ CCVT Farm Bureau	
5.2 Urban Water Management Practices									
1. Evaluate Low Impact Development opportunities to improve local groundwater recharge.	Medium	X					City of Paso Robles City of Atascadero		
2. Identify Water Conservation BMPs	Medium	X					City of Paso Robles City of Atascadero		
3. Develop urban landscaping guidelines to promote water use efficiency, reduce runoff and encourage groundwater recharge	Medium	X					City of Paso Robles City of Atascadero		
4. Investigate stormwater capture and recharge program	Medium		X			X	City of Paso Robles City of Atascadero		
5.3 Rural Residential Water Management Practices									
1. Develop a water conservatoin outreach and educaiton program for rural areas. The outreach program will inform rural groundwater users of the state of the Basin, include suggested conservation and efficiency measures, and if possible, provide incentives to water conservation and efficiency efforts	Medium		X			X	Partner	RCD's	Individual Residents
3. Develop a rural residential landscape ordinance to promote water use efficiency, reduce runoff and encourage groundwater recharge	Medium		X			X	Partner		Individual Residents
4. Facilitate programs to support homeowner water recycling, greywater reuse and stormwater capture (SLO GreenBuild does much of this already, the Planning Departmetn already has these in their code)	Medium		X			X			Individual Residents

Key:
DWR = California Department of Water Resources
DWSAP = Drinking Water Source Assessment and Protection Program
GAMA = Groundwater Ambient Monitoring and Assessment Program
GMP = Groundwater Management Plan
LUST = Leaky Underground Storage Tank
MWC = Mutual Water Company
OES = Office of Emergency Services
PRIOR – Paso Robles Imperiled Overlying Rights
PRWCA = Paso Robles Wine Country Alliance
RWQCB = Regional Water Quality Control Board
WRAC – Water Resources Advisory Committee

SLOC-FCWCD
SLOC - Planning
SLOC - Public Health

7.2 Implementation Schedule

The prioritization of project, programs, and strategies is included on Table 7-1. The result of the discussions was the identification of phases instead of a specific priority list. Implementation of the GMAs recommended in the Plan is scheduled in three phases:

7.2.1 Phase I - Ongoing Groundwater Management Activities:

These activities may continue throughout the planning horizon, including:

- Participation in Semi-annual GAC meetings.
- Preparation and distribution of annual reports.
- Development of funding mechanism to support ongoing groundwater management activities.
- Performance of groundwater monitoring and sharing of data.
- Coordination and cooperation with water entities, Monterey County, and State and federal agencies.
- Periodic review of groundwater monitoring and groundwater management activities
- Compliance with California Statewide Groundwater Elevation Monitoring Program requirements.
- Coordination of Plan with implementation of San Luis Obispo County's land use policies in the Basin.

7.2.2 Phase II-Near Term Projects (Next Three Years):

These projects are intended to be implemented within the next three years and include:

- Implementation of water conservation projects, including agricultural, urban, and rural residential water conservation projects.
- Development and continued implementation of best management practices for agricultural, urban, and rural residential water users.
- Identification of potential conjunctive use project.
- Identification of groundwater recharge areas.
- Improvements to the County's data management system consistent with the Data Enhancement Plan.
- Improvements to the groundwater monitoring network by installing some dedicated monitoring wells and bringing additional production wells into the network.
- Pursuit of grant funding opportunities to improve the groundwater monitoring network.
- Development of a strategy to update the existing groundwater model.
- Collection of the data sets necessary to update the existing groundwater model.
- Identification projects to utilize unallocated Nacimiento Project Water within the Basin.
- Identification water reuse and water recycling opportunities.
- Inclusion of Paso Robles Basin groundwater recharge and conjunctive use projects in update of San Luis Obispo County IRWMP.

7.2.3 Phase III-Long-Term Projects (Beyond Three Years):

These projects are planned for implementation beyond three years:

- Update and enhance the existing basin-wide groundwater model.
- Implementation of wastewater treatment and capacity enhancements.
- Development of conjunctive use projects.
- Identification and development of recharge projects.
- Continue implementation of conservation and demand management programs.

7.3 Annual Implementation Report

Each year, the District will prepare a report describing the progress made in implementing Groundwater Management Activities and the effects of these activities on meeting basin-wide and subarea BMOs. The report will include maps of spring groundwater elevations and tabular summaries of ongoing management actions. The report narrative will present details of implementation activities and describe developments in the basin that are not part of the groundwater management plan implementation but that impact groundwater conditions in the basin (e.g., hydrologic conditions, siting of new industrial facilities, newly identified contaminant plumes, and trends on water quality). The report is dependent on the Basin stakeholders providing groundwater data to the District through the GAC.

7.4 Financial Planning for Recommended Actions and Project Implementation

Progress toward the implementation of the GMP is contingent upon securing adequate funding to complete the program. Two avenues that are available for funding are grant funding and funds generated internally by the groundwater users in the Basin.

7.4.1 Grant Funding

Identified grant funding opportunities include the following:

- **Local Groundwater Assistance Act (AB303)** – There is anticipated to be one more round of AB303 funding to be available either in late 2010 or early 2011. This funding is focused on groundwater related projects such as improvements to the groundwater monitoring network. This program has a $250,000 limit for projects.
- **Proposition 84 – IRWMP Implementation Grants** – Projects must be included in the San Luis Obispo County IRWMP project list to be eligible for this funding opportunity. The project priority would be established through the IRWMP project prioritization process for the IRMWP. San Luis Obispo County is not planning to update their IRWMP (add new projects to the project list) until 2011.

7.4.2 Developing a Zone of Benefit

Revenue generated internally by local agencies through the development of a Zone of Benefit may provide a long-term source of funding available for implementation of the plan. Internally generated revenues are important because they are controlled by the member entities and represent a local commitment to plan implementation and achievement of the BMOs. Local financial support is often required by grant programs and by other sources of outside financing.

7.4.3 Joint Funding Agreement

The basin could develop a Joint Funding Agreement (either as a JPA or a MOU) to fund ongoing groundwater management activities in the Basin. This agreement would establish an annual budget to fund the continued and ongoing groundwater management efforts within the Basin. These funds could be used to finance:

- Annual groundwater level monitoring and reporting
- Other data collection efforts
- Technical investigations
- Model update and application

7.5 Periodic Review and Updated of the Plan

In addition to the annual reports of the state of the Basin and implementation progress, there is a need to periodically review and, if necessary, refine the Plan. These reviews would be scheduled at five-year intervals and would concentrate on analyzing information presented in the previous annual reports and consolidating the observations of GAC members and local agencies. The reviews would identify areas where the plan has been successfully implemented as well as areas where deficiencies were apparent. In areas where implementation has proceeded satisfactorily, the plan revision might include increasingly detailed information regarding the specifics of implementation. In areas where progress was less than anticipated, approaches would be discussed to either bring implementation of specific actions back on track or to change course and focus efforts on other actions believed to have a higher likelihood of success.

8 References

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Valentine, D.W., et al. Use of InSAR to Identify Land-surface Displacements Caused by Aquifer-System Compaction in the Paso Robles Area, San Luis Obispo County, California. USGS Open File Report 00-447, 1997.

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Appendix A Paso Robles GMP Preparation Resolutions

C Howard
File

San Luis Obispo County Flood Control and Water Conservation District Notice of Public Hearing Paso Robles Basin Groundwater Management Plan

Tribune 3/8/11

NOTICE IS HEREBY GIVEN that on March 22, 2011, at the San Luis Obispo County Flood Control and Water Conservation District (District) Board Room, 1055 Monterey Street (Monterey and Santa Rosa Streets), San Luis Obispo, California 93408, the District will hold a public hearing on whether or not to adopt a resolution of intention to draft a groundwater management plan (GMP) for the Paso Robles Groundwater Basin pursuant to California Water Code section 10750 et seq. This matter is scheduled to be heard on or after 9:00 a.m. on March 22, 2011. For further information, the Board's agenda will be available at **http://www.slocounty.ca.gov/archivedmeetings.htm** on or after March 16, 2011.

Dated: February 18, 2011

Julie L. Rodewald
County Clerk-Recorder and Ex-Officio Clerk of the Board of Supervisors

By: /s/*Sandy Currens*
Deputy Clerk

March 8, 14, 2011 6930415

Appendix B Paso Robles GMP Adoption Resolutions

Paso Robles Basin Groundwater Management Plan –

Adoption of the Groundwater Management Plan

Notices of adoption of the Groundwater Management Plan will be added as Agencies and Stakeholder groups adopt the Plan.

Appendix C Meeting Announcements

SAN LUIS OBISPO COUNTY
DEPARTMENT OF PUBLIC WORKS
Paavo Ogren, Director
County Government Center, Room 207 • San Luis Obispo, CA 93408 • (805) 781-5252
Fax (805) 781-1229 email address: pwd@co.slo.ca.us

December 31, 2008

Subject: Participation in the Development of the Paso Robles Groundwater Basin Management Plan

Dear Paso Robles Groundwater Basin Stakeholder:

Over the past several years, there have been many activities related to managing and monitoring the Paso Robles Groundwater Basin (Basin), including the completion of a comprehensive Basin study, update and computer model, Groundwater Level Measuring Program Evaluation, Paso Basin Agreement and Water Banking Feasibility Study. In addition, several organizations in the Basin have conducted, or will conduct, their own management, monitoring and project-specific activities. The City of Paso Robles (City), in cooperation with the San Luis Obispo County Flood Control and Water Conservation District (District), was recently awarded an AB 303 Local Groundwater Assistance Grant to consolidate these efforts into a comprehensive, coordinated, Senate Bill (SB) 1938-compliant Groundwater Management Plan (GMP) for the Basin.

Completion of a SB 1938-compliant GMP, will have many benefits, including:

- Provision of a framework for improved groundwater management to maintain groundwater levels, protect groundwater quality, and avoid subsidence.
- Development of a regional understanding of the groundwater setting and groundwater management opportunities in the Basin by building upon the existing organization of local water purveyors, agricultural interests, and stakeholders of the North County Water Forum to form the Groundwater Advisory Committee in the hopes of mitigating future conflicts.
- Identification of existing and future projects and programs that can be implemented to improve long-term water supply reliability in the Basin.
- Establishment of a locally-controlled and comprehensive approach to groundwater management that will be accepted in the Basin and recognized by other state and federal agencies and that can be used to pursue grant funding for groundwater related projects and programs in the Basin.

In order to address a broad range of groundwater related issues in the Basin, your organization is invited to participate in the development of the GMP through the public outreach and stakeholder involvement process, including participation in the Groundwater Advisory Committee.

Please complete and return the enclosed survey, indicating your organization's willingness to participate in the development of a Groundwater Management Plan for the Paso Robles Groundwater Basin. A copy of the scope of work and project schedule to complete the GMP is also enclosed for your reference.

On behalf of the City of Paso Robles and all of the entities that depend upon the water in the Paso Robles Groundwater Basin, I hope your organization is able to join us in taking this proactive, cooperative step. If you have any questions, please contact me (805-781-1016; choward@co.slo.ca.us) or the City's Water Resources Manager, Christopher Alakel (805-237-3861; calakel@prcity.com). We hope to see you at the Project Kick-off Meeting on January 15th – flyer enclosed.

Sincerely,

COURTNEY HOWARD, P.E.
Water Resources Engineer

Enclosures

c: Christopher Alakel, City of Paso Robles
Dean Benedix, Utilities Division Manager
Sylas Cranor, Engineer

File: CF 500.132.01

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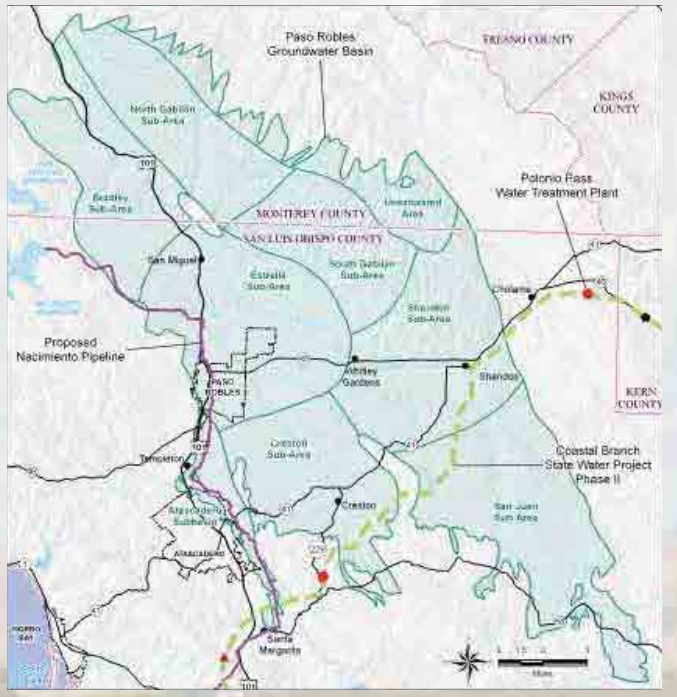
Introducing

The Paso Robles Groundwater Basin Management Plan

San Luis Obispo County recently completed an Integrated Regional Water Management Plan. The plan contains groundwater monitoring and management objectives for the groundwater basins in the County, including the Paso Robles Groundwater Basin. In response to these objectives, The City of Paso Robles and San Luis Obispo County are leading the preparation of a groundwater management plan (GMP) for the Paso Robles Groundwater Basin. The GMP will address groundwater conditions, identify local and basin-wide groundwater issues, and outline measures to protect groundwater resources within the plan area (shown at right).



A Project Kickoff Meeting will be held:

Thursday, January 15, 2009
5 p.m. — 7 p.m
City of Paso Robles
Emergency Operations Center
900 Park Street

The meeting will include a review of the project purpose, approach, and schedule. Additionally, the formation of the Groundwater Advisory Committee will be discussed. The purpose of the Groundwater Advisory Committee is to assist in developing the GMP. The draft GMP is scheduled to be released in July 2009, with the final GMP due December 2009.

Parties interested in the GMP are encouraged to participate in the planning process by attending public meetings scheduled by the Groundwater Advisory Committee.

Paso Robles Groundwater Basin Groundwater Management Plan
Project Schedule (updated Dec 10, 2008)

Task Name	2008	2009											
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1 - Administrative Requirements of Groundwater Management Plan Process													
Task 2 - Public Outreach and Stakeholder Involvement		△	△		△			△ WRAC		△			△ WRAC
Task 3 - Identify Groundwater Issues and Develop Basin Management Objectives				TM1									
Task 4 - Water Demand and Supply Analysis					TM2								
Task 5 - Prepare 2009 Annual Groundwater Report			SAP										DMS GWR
Task 6 - Prepare Groundwater Management Plan								DGMP					FGMP
Task 7 - Technical Review - QA/QC		SAP	TM1	TM2			DGMP			DMS GWR		FGMP	
Task 8 - Project Management													

△ Groundwater Advisory Committee (GAC) Meetings
WRAC - Water Resouce Advisory Committee Meetings

TM 1 - Groundwater Issues and Provisional BMOs
TM 2 - Exising and Projected Land and Water Use
SAP - Sampling and Analysis Plan
DMS - Groundwater Data Management System
GWR - 2009 Annual Groundwater Report
DGMP - Draft Groundwater Management Plan
FGMP - Final Groundwater Management Plan

Task Specified Activity

Ongoing, Intermittent Activity

Exhibit A

Scope of Work

The Scope of Work is divided into the following eight major tasks:

Task 1 – Administrative Requirements of Groundwater Management Plan Process
Task 2 – Public Outreach and Stakeholder Involvement
Task 3 – Identify Groundwater Issues and Develop Basin Management Objectives
Task 4 – Water Demand and Supply Analysis
Task 5 – Prepare 2009 Annual Groundwater Report
Task 6 – Prepare Groundwater Management Plan
Task 7 – Technical Review – QA/QC
Task 8 – Project Management

Task 1 – Administrative Requirements of Groundwater Management Plan Process

The purpose of this task is to provide support to satisfy the administrative requirements for completing an SB 1938-compliant Plan. These administrative requirements occur primarily at the beginning and end of the preparation of the Plan. The consultant will assist the project participants (City, County, and other agencies that state intent to adopt plan) in:

- Establishing a public participation/public involvement process including:
  - Inviting and encouraging public participation in the development of the Plan.
  - Forming the Paso Robles Basin Groundwater Advisory Committee (Paso Robles Basin GAC) of interested parties and stakeholders. The North County Water Forum will be used as the starting point for the formation of the Paso Robles Basin GAC.
  - Reviewing notices prior to publication of City Council and other meetings in local newspapers regarding development of the Plan; notice of intent to develop the Plan; notice of the availability of the draft Plan; and notice of the availability of the final Plan to be circulated for agency adoption.

- Assisting the project participants in complying with the public involvement requirement in SB 1938.
- Assisting the project participants with other administrative procedures.

Task 2 – Public Outreach and Stakeholder Involvement

This task includes activities associated with the public outreach and stakeholder involvement process, such as communication with Basin stakeholders and other interested parties. There is an established and very active stakeholder process in northern San Luis Obispo County. This process has been used extensively to address issues and build consensus among a very diverse group of stakeholders.

The consultant will support the City and County with this task. This task involves 14 meetings:

- Ten regularly scheduled workshops for the Paso Robles Basin GAC to guide development of the Plan, review of project deliverables, and receipt of comments on the plan development and interim deliverables.
- Three briefings to the WRAC at selected times in the project schedule to provide meaningful updates to the WRAC.
- Paso Robles City Council and possibly County Board of Supervisors briefings.
- Up to four additional briefings will be provided to the local advisory bodies during the preparation of the Plan to keep the local stakeholders and interested parties informed of the progress of the Plan and to elicit feedback.

Additional efforts under this task may include:

- Circulation of newsletters in advance of the meetings as part of public outreach and stakeholder involvement.
- Providing visual aids, copies of presentations and deliverables, and refreshments at meetings.
- Providing meeting agenda and minutes as well as other announcements regarding the Plan on the City's and County's websites and distributing this information at the meetings.
- Coordinating with local and federal agencies.

Task 3 – Identify Groundwater Issues and Develop Basin Management Objectives

The purpose of this task is to identify the groundwater management issues within the Plan Area and develop BMOs that identify the groundwater management activities that are linked to each BMO. The BMOs will include objectives for water levels, water quality, and land subsidence. The activities associated with the development of BMOs will address the groundwater management components and may be organized into the following groups.

- Groundwater protection issues may include:
  - Control of saline water
  - Identification of well protection and recharge areas
  - Regulation of the migration of contaminated groundwater
  - Administration of a well abandonment and well destruction program
  - Identification of well construction policies
  - Coordination with agencies responsible for groundwater contamination cleanup, recharge, storage, recycling, and extraction projects
  - Review of land use plans and coordination with planning agencies to assess activities that create a reasonable risk for groundwater contamination
- Groundwater use/recharge issues may include:
  - Prevention and mitigation of conditions of overdraft
  - Replenishment of groundwater extracted by water producers
  - Monitoring of groundwater quality and storage levels
  - Facilitating conjunctive use operations

The groundwater subareas listed below were identified in the Basin Study (Fugro, 2002) based on water quality, source of recharge, groundwater movement, and contours on the base of permeable sediments. The Annual Report (Todd Engineers, 2007) used these same subbasin/subarea delineations. It is expected that the BMOs will be developed based upon the groundwater subarea delineations from the Basin Study:

- North Gabilan Subarea
- Bradley Subarea
- South Gabilan Subarea
- Estrella Subarea
- Creston Subarea
- Shandon Subarea
- Atascadero Subbasin

This task will be led by the consulting team. Independent technical review of this task will be completed by the consulting team as described in Task 7. The deliverable for this task will be a technical memorandum documenting the groundwater issues and provisional BMOs for each subarea.

Task 4 – Water Demand and Supply Analysis

The purpose of this task is to document the current and future land use and the associated water uses in the Basin based on readily available information. There are three land use and water use planning activities in the County that are coincident with the proposed schedule for the development of the Plan whose scope includes analyzing the water demand and water supply in the Basin.

- **Resource Capacity Study** - In its June 5, 2007, meeting, the Board recommended a Level of Severity I designation for the Basin, indicating a low immediacy of resource deficiency. This designation was made with reference to the 1980-1997 groundwater level decreases in the Estrella subarea and to increases in the extent of overlying land uses, including ranchettes, golf courses, and vineyards. As a result of this designation, County staff was directed to prepare a Resource Capacity Study that will focus on the area of groundwater level decrease. A draft Resource Capacity Study is expected to be available in January 2009.

- **Conservation Element of the County General Plan** - The Conservation Element of the County's General Plan is being updated to improve, consolidate, and revise the existing policies and programs, including those related to water resources. "Cutting edge" policies will be developed related to green building, watershed protection, water conservation, biological resource protection, and conservation-oriented land use patterns such as smart growth that may have an impact on future groundwater basin management efforts. The Conservation Element of the County General Plan will be completed by the County Planning Department. A draft Conservation Element is anticipated to be available in November 2008.

- **Countywide Master Water Plan** - In addition, the Countywide Master Water Plan update is scheduled for 2010. Incorporating recent documents such as urban water management plans, general plan updates, and water/wastewater master plans, the Countywide update will include current and future water use projections for water planning areas. The Groundwater Management Plan development will coincide with the Master Water Plan development and it is anticipated that the consultant and the County Public Works Department will support one another during the process.

The County Department of Planning staff will be responsible for completing the Resource Capacity Study and Conservation Element, and the Public Works staff will be responsible for completing the Countywide Master Water Plan update described above.

The *Update for the Paso Robles Groundwater Basin* (Update) (Todd Engineers, December 2007) provided an overview of the current conditions of the Basin building on the Groundwater Basin studies (Fugro 2002 and 2005). The report provided an update from 1997 through 2006 on rainfall, groundwater levels and storage, and groundwater management. An update of pumping in the Basin will be completed in the next few months The Update report and pumping update will become part of the Resource Capacity Study. The first Annual Groundwater Report, prepared as part of this Plan, will include monitoring data collected in 2007 through 2009 and discuss changes in land use, water use, pumping, groundwater levels, and groundwater quality.

Independent technical review of this task will be provided by the consulting team as described in Task 7. The deliverable for this task is a technical memorandum documenting the existing and expected future land and water use conditions. In addition, the GIS files used in the analysis will be provided to the City and County Planning Department.

Task 5 – Prepare 2009 Annual Groundwater Report

The purpose of this task is to build upon the existing groundwater monitoring taking place in the Basin and to formalize the groundwater monitoring program. This includes the following activities:

- Prepare a Sampling and Analysis Plan (SAP) that includes monitoring protocols for the Basin.
- Develop a data management system to store, manage, analyze, and present monitoring data.
- Review available data to identify wells for each subarea that represent the overall trends for use in development of provisional BMOs.
- Prepare groundwater level maps for spring and fall 2009.
- Summarize groundwater level and quality data.
- Develop the format for future annual groundwater reports.
- Prepare the 2009 Annual Groundwater Report.

This task will be led by the consulting team. The deliverables for this task include the Sampling and Analysis Plan and the 2009 Annual Groundwater Report, which will present the results of the 2007 through 2009 monitoring activities. In addition, this task will include a data management system. The data management system software will be non-proprietary and the consultant will provide the County and City with all the data files and provide general guidance in operation of the data management system, if needed.

Independent technical review of this task will be provided by the consulting team as described in Task 7. In addition, the draft 2009 Annual Groundwater Report will be presented to the Paso Robles Basin GAC, WRAC, and interested local advisory committees in order to obtain review and comment by the stakeholders and interested parties.

Task 6 – Prepare Groundwater Management Plan

A draft and final version of the Plan will be completed as part of this task. The draft document will be made available to the project participants, stakeholders, and DWR for review and comment. The final document will be prepared, based on information collected on the draft document. The final Plan will be provided to the project participants for adoption. Project costs associated with this task are for the production and distribution of 10 draft and 20 final copies of the Plan.

This task will include the preparation of an implementation plan that will be used to guide groundwater management in the Basin and support other planning efforts such as the IRWMP. The project participants and stakeholders will develop the implementation plan, which will address:

- Continuation of the groundwater monitoring program, including the analysis and reporting of annual groundwater conditions
- Continuation of monitoring groundwater protection efforts
- Ongoing planning for groundwater recharge and conjunctive use opportunities
- Planning to periodically update the Plan as additional information is developed
- Identifying funding for continued groundwater management activities in the subbasin.

This task will be led by the consulting team. Independent technical review of this task will be completed by the consulting team as described in Task 7. In addition, the draft GMP will be presented to the Paso Robles Basin GAC, the WRAC and interested local advisory committees in order to get review and comment by the stakeholders and interested parties.

Task 7 – Technical Review – QA/QC

This task includes an independent technical review by the members of the consulting team experienced in groundwater management, but not directly involved in the development of this GMP. This internal QA/QC will provide additional review and expertise to the project to ensure that it meets the expectations of the local project participants and stakeholders, provides a vision and framework for the implementation of groundwater management in the Basin, and meets the requirements for SB 1938. The technical review is expected to focus on four specific areas:

- Identification of groundwater issues and development of BMOs (Task 3)
- Documentation of the water demand and supply analysis (Task 4)
- Preparation of the Sampling and Analysis Plan and the 2009 Annual Groundwater Report (Task 5)
- Review of the draft groundwater management plan including the implementation plan (Task 6).

Task 8 – Project Management

This task includes general project management and coordination during throught the project. This task includes:

Preparing monthly invoices and progress reports

- The progress report is to conclude a brief narrative of the task that are underway and their progress to date. Also, the consultant shall develop and maintain a project scheduled that will be updated regularly and submitted with the monthly progress reports.

Project Deliverables

The project deliverables identified in the work plan are listed below.

- Participation in six project meetings and up to eight briefings **(Task 2)**
- Technical memorandum documenting BMOs **(Task 3)**
    - Techical memorandum draft and final report – A task outline and approach shall be submitted, reviewed, and approved prior to commencing with a TM Draft and final.
- Interim technical memorandum documenting water use and supply analysis **(Task 4)**
    - Technical memorandum draft and final report – A task outline and approach shall be submitted, reviewed, and approved prior to commencing with a TM Draft and final.
- Sampling and Analysis Plan and Groundwater Report Draft, and Final **(Task 5)**
- 2009 Annual Groundwater Report **(Task 5)**
- Water level and water quality data management system **(Task 5)**
- Draft and final Plan **(Task 6)**
- Monthly progress reports and schedule updates **(Task 8)**

NORTH COUNTY WATER FORUM

Templeton Community Services District
420 Crocker Street
Templeton

Thursday, September 4, 2008
5:00 to 6:30 p.m.

Paso Robles Groundwater Basin Topics for Discussion:

- Agenda Amendments

- Relationships between Paso Basin planning/projects, local planning/projects and county-wide planning/projects

- Current and Future Basin Pumping Analysis

- Resource Capacity Study of the area of significant groundwater level decline

  Results of the pumping analysis will be incorporated into a draft RCS currently scheduled to be presented during the December NCWF meeting.

- Grant to complete a Paso Robles Basin Groundwater Management Plan

  The State Department of Water Resources has funded the grant application to develop a Groundwater Management Plan for the Paso Robles Groundwater Basin. The original Groundwater Management Plan Grant Application is posted at www.slocountywater.org/site/Water%20Resources/Reports/index.htm, however it is very large (40 mb). A hard copy for viewing at the Public Works Department in San Luis Obispo or CD upon request is available. The scope and schedule will be modified to reflect the reduced funding amount of $208,000 and Grant Agreement deadline of May 15, 2010.

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN
GROUNDWATER ADVISORY COMMITTEE MEETING

Emergency Operations Center
900 Park Street
Paso Robles

Thursday, January 15, 2009
5:00 to 7:00 p.m.

All Paso Robles Groundwater Basin (Basin) stakeholders are invited to attend this Paso Robles Groundwater Basin Management Plan (GMP) Kick-off Meeting.

Topics for Discussion:

- Scope of Work
- Schedule
- Participation

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN
GROUNDWATER ADVISORY COMMITTEE MEETING

Emergency Operations Center
900 Park Street
Paso Robles

Thursday, November 12, 2009
5:30 to 7:30 p.m.

All Paso Robles Groundwater Basin (Basin) stakeholders are invited to attend this Paso Robles Groundwater Basin Management Plan (GMP) re-Kick-off Meeting. Grant funding is available again to move forward with this important project. See attached brochure for additional information.

Topics for Discussion:

- Scope of Work
- Schedule
- Participation

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN
GROUNDWATER ADVISORY COMMITTEE MEETING

Paso Robles City Hall Council Chambers
1000 Spring Street
Paso Robles

Thursday, December 2, 2010
5:30 to 7:30 p.m.

All Paso Robles Groundwater Basin (Basin) stakeholders are invited to attend.

The meeting presentation and the Draft Groundwater Management Plan will be available on the following websites by Thursday:

www.prcity.org/government/

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

The purpose of the meeting will be to provide an overview of the Draft Plan in order to facilitate your review, and discuss components of the Plan not addressed previously.

Comments on the Draft Plan will be due January 5th in order to provide a proposed final draft in advance of a February meeting.

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN
GROUNDWATER ADVISORY COMMITTEE MEETING

Paso Robles City Hall Council Chambers
1000 Spring Street
Paso Robles

Thursday, February 25, 2010
5:30 to 7:30 p.m.

All Paso Robles Groundwater Basin (Basin) stakeholders are invited to attend.

Topics for Discussion:

- Basin Issues
- Basin Management Objectives

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN

ATASCADERO, ESTRELLA, AND CRESTON SUBAREAS
GROUNDWATER ADVISORY COMMITTEE MEETING

Paso Robles City Hall Council Chambers
1000 Spring Street
Paso Robles

Monday, April 19, 2010
5:30 to 8:30 p.m.

As the next step in developing the Groundwater Management Plan for the Paso Basin, the project team will be holding a workshop to develop basin management objectives and potential actions for the **Atascadero, Estrella, and Creston subareas**. While the three subareas will meet at the same time, we will be breaking into your subareas for separate discussions.

A similar workshop for the San Juan, Shandon, North Gabilan, South Gabilan and Bradley subareas will be held at a later date.

In order to have a successful workshop, we would like at least one representative to be available from the following entities/groups (thank you to those that have responded):

- The agricultural community (vineyards, wineries, ranching, other crops)
- Rural residents from each subarea
- RCD and/or NRCS
- Advisory Bodies
- PRIOR
- San Miguel CSD
- City of Paso Robles
- Templeton CSD
- Atascadero MWC
- City of Atascadero

Any other entities/groups that can help to provide input and distribute information for these subareas are also welcome.

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN

SAN JUAN, SHANDON, BRADLEY AND GABILAN SUBAREAS
GROUNDWATER ADVISORY COMMITTEE MEETING

Shandon High School Gym
First Street
Shandon

Monday, May 10, 2010
7:00 p.m.

As the next step in developing the Groundwater Management Plan for the Paso Basin, the project team will be holding a workshop to develop basin management objectives and potential actions for the **San Juan, Shandon, Bradley, North Gabilan and South Gabilan subareas**. While the five subareas will meet at the same time, we will be breaking into your subareas for separate discussions.

In order to have a successful workshop, we would like at least one representative to be available from the following entities/groups (thank you to those that have responded):

- Shandon
- Green River MWC
- the agricultural community (vineyards, wineries, ranching, other crops)
- rural residents from each subarea
- Upper Salinas-Las Tablas RCD and/or NRCS
- Shandon Advisory Council
- PRIOR

Any other entities/groups that can help to provide input and distribute information for these subareas are also welcome.

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN
GROUNDWATER ADVISORY COMMITTEE MEETING

Paso Robles City Hall Council Chambers
1000 Spring Street
Paso Robles

Monday, August 2, 2010
5:30 to 7:30 p.m.

All Paso Robles Groundwater Basin (Basin) stakeholders are invited to attend.

A draft agenda is attached for your review.

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN
GROUNDWATER ADVISORY COMMITTEE MEETING

Paso Robles City Hall Council Chambers
1000 Spring Street
Paso Robles

Thursday, February 10, 2010
5:30 to 7:30 p.m.

All Paso Robles Groundwater Basin (Basin) stakeholders are invited to attend.

The revised Draft Groundwater Management Plan and Monitoring Plan are available on the following websites:

www.prcity.org/government/

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

Additional appendices will be added to the websites over the next several days.

The purpose of the meeting will be to review changes to the Draft Plan, discuss the composition of the Groundwater Advisory Committee and potentially consider or nominate at-Large members, and discuss the next steps in Plan implementation.

Key updates to the Plan included:

- More clearly defining the role of the Paso Robles Wine Country Alliance as to their members, rather than the broader agricultural community.
- Refining the role of the County in Plan implementation.
- Incorporating the results of the Governance Subcommittee meeting into the governance for Plan implementation.
- Incorporating general edits and comments.

Questions? Please contact Courtney Howard at (805) 781-1016 or choward@co.slo.ca.us

View Basin reports online at:

http://www.slocountywater.org/site/Water%20Resources/Water%20Forum/index.htm

Appendix D BMO Workshop Summaries

Summary of Basin Management Objective Workshop
For the Atascadero Subbasin

The draft Basin Management Objectives (BMOs) for groundwater levels in the Atascadero Subbasin were discussed and developed by stakeholders of Atascadero Subbasin at the Paso Robles Groundwater Basin Management Plan BMO Workshop held on April 19 at the City of Paso Robles City Council Chambers. The stakeholders from the Atascadero Subbasin that attended the Workshop are listed below:

Name	Affiliation
Della Barret	Resident (private well or AMCW)
Kathy Sweet	Resident (private well or AMCW)
Keith Larson	City of Paso Robles
Bob Roos	Resident (private well or AMCW)
Jackie Magill	Resident (private well or AMCW)
John Neil	Atascadero Mutual Water Company
John Hollenbeck	Resident (private well or AMCW)
Carrie Jones	Resident (private well or AMCW)
Jay Short	Templeton CSD
Susan Litteral	Resident (private well or AMCW)/NRCS

Jim Magill recorded the information discussed by the Atascadero Subarea Stakeholders. The Atascadero Subbasin Stakeholders generally reached consensus on most of the issues presented below.

Basin Management Objectives are intended to provide quantifiable and measureable targets so that progress towards improved groundwater management can be tracked. BMOs are being developed for subareas within the Paso Robles Groundwater Basin (Basin) to represent the differing groundwater conditions and necessary management activities.

Groundwater Management Activities (GMAs) are intended to identify the steps or actions taken to meet the BMOs. It should be recognized that both BMOs and GMAs should be evaluated and updated routinely (every few years) as additional information is collected, or in response to changing conditions.

Groundwater Levels in the Atascadero Subarea are affected by:

- Annual hydrologic conditions
- Changes in water demands that are met with groundwater

There are currently about 150 wells located within the limits of the Paso Robles Groundwater Basin that are monitored by the San Luis Obispo County Department of Public Works and the Monterey County Water Resources Agency. These wells are used to track the changes in groundwater level trends through time at a specific location, or across an area for a specific date. The changes in groundwater levels in the Atascadero Subbasin are currently recorded at 33 wells that are included in the groundwater monitoring network.

Groundwater Levels in the Atascadero Subbasin are affected by:

- Annual hydrologic conditions
- Changes in water demands that are met with groundwater

The rate of decline changes through time in response to changing hydrologic conditions and changes in the amount of local groundwater pumping. The composite hydrograph of four wells (currently in the monitoring network) was selected to represent the conditions in the subbasin is shown on Figure 1. These wells will be used as an indicator to how groundwater levels in the subarea are changing over time.

Groundwater levels in the Atascadero Subbasin tend to have a greater range in annual response than other subareas, with average groundwater levels increasing or decreasing by up to 15 feet in single years. The overall trend of the average groundwater levels has remained relatively constant since the early 1980s with groundwater levels rising and falling in response to changing hydrologic conditions and increasing demands. The 2009 average groundwater levels are within ten feet of the 1981 levels as shown on Figure 1. Based on the pattern exhibited on this figure, a single wet year could return the average groundwater levels to the 1981 conditions. It is not clear how the increase in demands since the late 1990s likely contributes to the overall declining groundwater levels of about 30 feet during the 1997 to 2009 period.

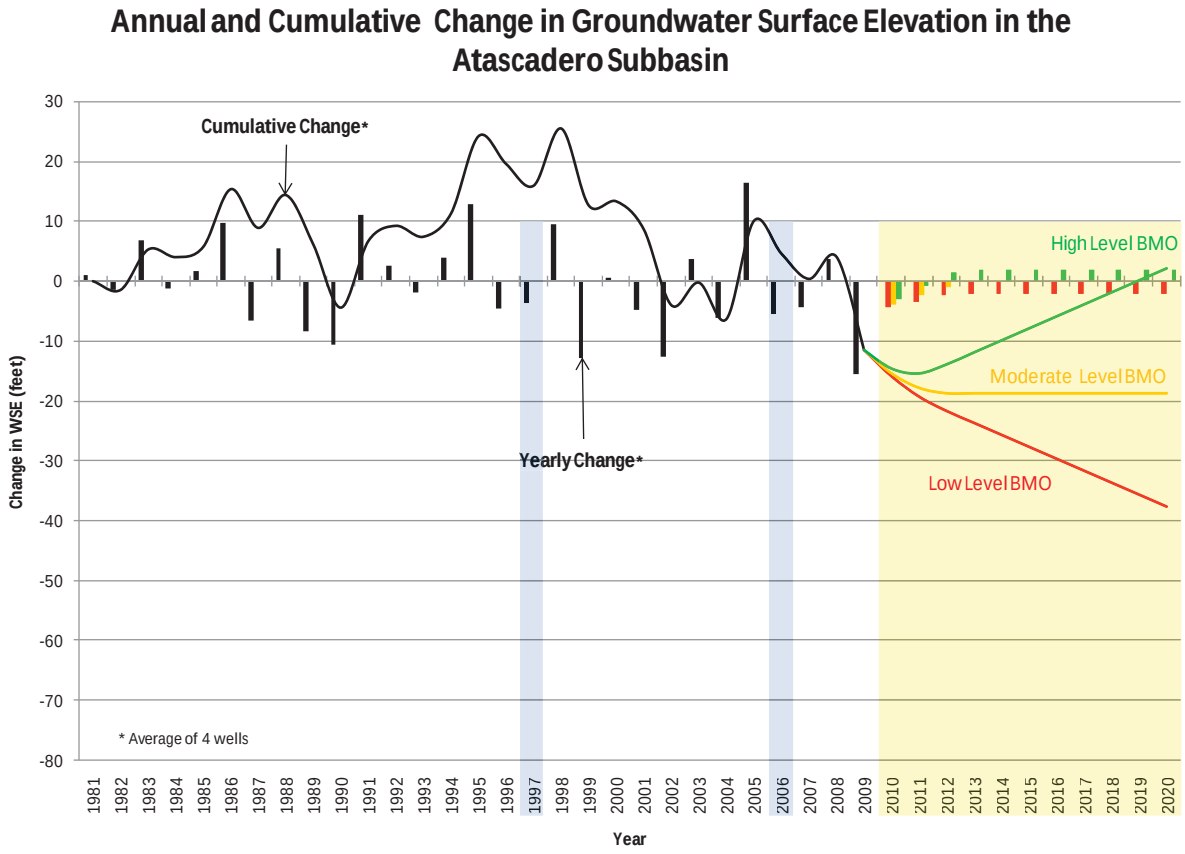


Figure 1. Composite Hydrograph of Four Selected Wells in the Atascadero Subbasin

The 2010 to 2020 period included on Figure 1 shows potential range of changes in groundwater levels in the subarea under different levels of BMOs. Low level BMOs would be expected to result in a continuing decline or groundwater levels similar to those experienced during the 1997 to 2009 period. The moderate level BMO would eventually result in no change in groundwater levels (stabilized groundwater levels). The high level BMO would result in improvement of groundwater levels over time. These projected groundwater levels are intended to show the differences in groundwater levels based on target groundwater levels (BMOs) selected for the subarea, and the magnitude of the GMAs implemented. Additional analysis is needed to quantify the result (in terms of groundwater levels) due to the implementation of GMAs in the subarea.

Water demands in the Atascadero Subarea met by groundwater increased by about 1,000 acre-feet during the 1997 to 2006 period as shown on Table 1. This increase in demands may have contributed to the decline of groundwater levels during this period. These higher demands, along with drier conditions during the 2006 to 2009 period, likely contributed to the increased rate of groundwater level decline (about five feet per year) during this period.

Table 1. Estimated Water Demands in the Atascadero Subarea for 1997 and 2006

GROUNDWATER DEMAND BY DEMAND TYPE FOR 1997 AND 2006 FOR THE ATASCADERO SUBBASIN							
Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	1,348	11,735	0	430	2,032	15,545
Estimated 1997 Demand	(acre-feet)	1,023	11,376	0	300	1,800	14,499
Difference (2006 less 1997)	(acre-feet)	325	359	0	130	232	1,046

2006 Demand Assumptions: Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)

1997 Demand Assumptions: 1997 Demands form Paso Robles Groundwater Basin Study (Fugro, 2002)
Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.
1997 Municipal demand includes City of Paso Robles groundwater pumping from river wells(3,933 acre-feet)
Small community demands included in rural domestic demand

Draft Basin Management Objectives

The Atascadero Subbasin stakeholders determined that an acceptable draft BMO for groundwater levels in the Atascadero Subbasin would include stabilizing groundwater levels at about the 2009 level as presented in the composite hydrograph (average of four wells). This draft BMO had strong consensus among the participants.

Potential Groundwater Management Activities

The following Groundwater Management Activities (GMAs) were identified by the Atascadero Subbasin Stakeholders to stabilize groundwater levels in the Atascadero Subbasin. The potential benefit from these GMAs has not been quantified for the Atascadero Subbasin (in terms of changes in groundwater

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levels), so it has not been determined if implementation of the GMAs will result in stabilized groundwater levels.

GMA 1: Increase monitoring and reporting on groundwater conditions: This GMA includes expanding the groundwater monitoring network in the Atascadero Subbasin through the addition of new wells to the volunteer monitoring network.

Groundwater level measurements are currently taken by the County in the spring and fall of each year. Spring water levels will be used to track year-to-year changes and long-term trends in groundwater levels because they represent more stable conditions. Groundwater levels will be made available on a regular basis (semi-annually) within two months after most current readings, and will be included in the Paso Robles Groundwater Basin Annual Report. This level of monitoring and reporting of groundwater levels should be sufficient for determining the effectiveness of the GMAs at this time. Additional monitoring and reporting may be needed at some future date.

While this GMA does not directly result in changes in groundwater levels, it will help communicate conditions to individuals and support implementation of groundwater management activities in the subarea.

The San Luis Obispo County Flood Control and Water Conservation District would likely be the lead entity of a cooperative group formed to collect, organize, and report on groundwater conditions in the Paso Robles Groundwater Basin on a regular basis. Atascadero Mutual Water Company, City of Paso Robles and Templeton Community Services District collect water level data that is provided to the District for inclusion in the monitoring program.

GMA 2: Increase water conservation education and implementation: This GMA includes increasing the awareness of the impact of water conservation on reducing groundwater pumping. The effectiveness of the water conservation program will be difficult to verify for rural and agricultural areas without metering well production. The effectiveness of the GMA will be based on the changing behavior of individual water users and impacts on groundwater level trends in the area. The effectiveness of this GMA will be evaluated on an annual basis.

This GMA had large consensus of the Atascadero Subbasin stakeholders. Some of the specific water conservation activities identified include:

- Municipal water purveyors have implemented some level of conservation to date. The effectiveness of these efforts can be tracked by the delivery volumes. Because municipal water demands compose the largest single demand type in the subbasin, there is the greatest opportunity for reduction in groundwater pumping. Based on 2006 municipal demands in the Atascadero Subbasin, a 10% level conservation could result in a reduction in demand of about 880 acre-feet per year.
- Agricultural Water Conservation (opportunities for reductions in groundwater pumping resulting from agricultural conservation programs may be limited in the Atascadero Subbasin due to the comparatively small agricultural demand). Based on 2006 agricultural

demands in the Atascadero Subbasin, a 10% level conservation could result in a reduction in demand of about 130 acre-feet per year.

- Rural Residential Water Conservation (opportunities for reductions in groundwater pumping resulting from rural residential conservation programs may be limited in the Atascadero Subbasin due to the comparatively small rural residential demand). Based on 2006 rural domestic demands in the Atascadero Subbasin, a 10% level conservation could result in a reduction in demand of about 200 acre-feet per year. Water conservation programs in the rural residential sector may focus on the following:
    - Landscape Water Use
    - Consider controls on non-agricultural ponds
    - Development of conservation outreach and incentive programs implemented by San Luis Obispo County

Responsibility for implementing certain components of this GMA may include both the San Luis Obispo County Department of Planning and Building, and the San Luis Obispo County Flood Control and Water Conservation District. The Atascadero Mutual Water Company, City of Paso Robles, and Templeton Community Services District are responsible for implementing water conservation programs within their service areas.

GMA 3: Managing the growth and corresponding increase in water demands: This GMA includes identifying potential land use planning activities that may be used to reduce the rate of growth of water demand in the subbasin. In areas outside the jurisdiction of the cities of Atascadero and Paso Robles, land use planning responsibilities are the responsibility of the San Luis Obispo County Department of Planning and Building. The cities have implemented land use policies that limit water use rates and promote water conservation, such as limiting turf in new development. In addition, higher water rates paid by city water customers encourage efficient water use. Any policies established in areas where San Luis Obispo County has jurisdiction would be applied to the entire Basin, not just this subarea. This GMA may include:

- Building moratorium on lot splits and subdivisions
- Discretionary lots splits would require meters on the new well and the existing well
- No net increase in water use resulting from additional rural residential development
- Promote greywater use
- Minimize turf areas
- Meter new wells
- Offset water use
- Explore opportunities for residential rainwater harvesting

Responsibility for implementing this GMA may include both the San Luis Obispo County Department of Planning and Building and the cities of Atascadero and Paso Robles.

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GMA 4: Maximize the amount of Nacimiento Project Water in the Subbasin: This GMA includes utilizing the existing Nacimiento Project Water already acquired for use in the subbasin, and explore opportunities to utilize unassigned Nacimiento Project Water.

The San Luis Obispo County Flood Control and Water Conservation District would be one of the lead agencies responsible for implementing this GMA. Local water purveyors would be responsible for developing and implementing projects to acquire supplies from the Nacimiento Water Project.

GMA 5: Consider storm water management opportunities to increase local groundwater recharge: This GMA includes evaluating the feasibility of recharging storm water runoff in the streams and creeks of the Basin. The potential benefit (in groundwater recharge) has not been evaluated for this GMA at this time.

The San Luis Obispo County Flood Control and Water Conservation District and Department of Planning and Building, and City of Atascadero would likely be the lead agencies responsible for implementing this GMA.

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Summary of Basin Management Objective Workshop
For the Bradley and North Gabilan Subareas

The draft Basin Management Objectives (BMOs) for groundwater levels in the Bradley and North Gabilan Subareas were discussed and developed by stakeholders at the Paso Robles Groundwater Basin Management Plan BMO Workshop held on May 10 at the Paso Robles City Council Chambers. The stakeholders from the subareas that attended the workshop are listed below:

Name	Affiliation
Robert Johnson	Monterey County Water Resources Agency
Keith Larson	City of Paso Robles
Christopher Alakel	City of Paso Robles
Courtney Howard	San Luis Obispo County

Courtney Howard recorded the information discussed by the stakeholders.

Basin Management Objectives are intended to provide quantifiable and measureable targets so that progress towards improved groundwater management can be tracked. BMOs are being developed for subareas within the Paso Robles Groundwater Basin (Basin) to represent the differing groundwater conditions and necessary management activities.

Groundwater Management Activities (GMAs) are intended to identify the steps or actions taken to meet the BMOs. It should be recognized that both BMOs and GMAs should be evaluated and updated every few years as additional information is collected, or in response to changing conditions.

Groundwater Levels in the Bradley and North Gabilan Subareas are affected by:

- Annual hydrologic conditions
- Changes in water demands that are met with groundwater

There are currently about 150 wells located within the limits of the Paso Robles Groundwater Basin that are monitored by the San Luis Obispo County Department of Public Works and the Monterey County Water Resources Agency. These wells are used to track the changes in groundwater level trends through time at a specific location, or across an area for a specific date.

The changes in groundwater levels in the Bradley Subarea are currently recorded at one well that is included in the groundwater monitoring network of Monterey County Water Resources Agency (MCWRA). This well is located near the Salinas River just north of the subarea boundary, and may not be representative of groundwater levels throughout the Bradley or North Gabilan Subareas. The lack of data prevents the development of groundwater level hydrographs, or composite hydrographs as developed for other subareas. The lone hydrograph available for these two subareas is shown in Figure 1.

The hydrograph shown in Figure 1 is for a well located near the Salinas River downstream of the confluence of the Salinas River and the Nacimiento River. It appears that groundwater levels in this well reflect the interaction of the Salinas River and the alluvial aquifer materials adjacent to the river. Flows

from the Salinas River, along with releases from Nacimiento Reservoir, help maintain groundwater levels in alluvial aquiver near the Salinas River.

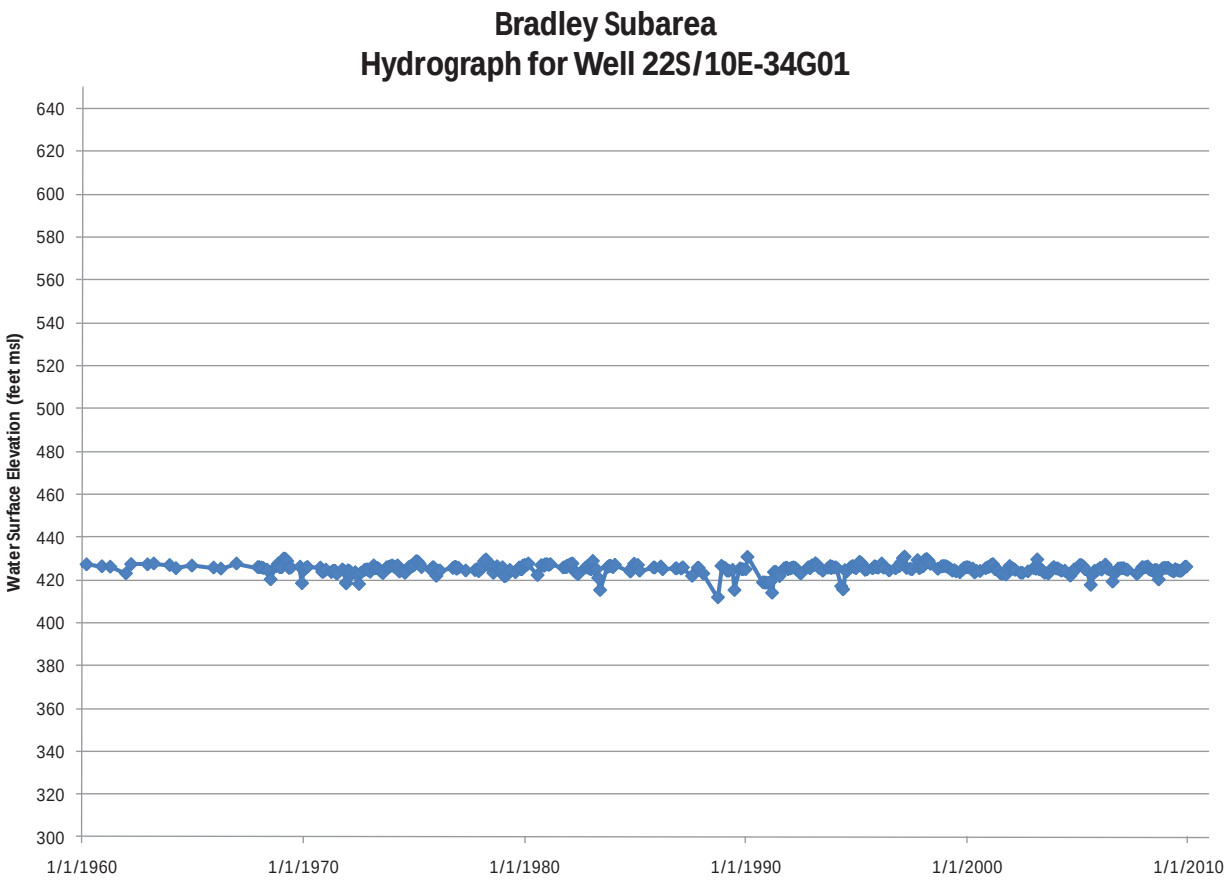

Figure 1. Well Hydrograph in the Bradley Subarea

At this time, we are not aware of any reports or anecdotal information that suggests groundwater levels in the Bradley Subarea or the North Gabilan Subarea are declining to the point of causing problems for local groundwater users.

Water demands in the Bradley Subarea met by groundwater have increased by total of about 1,000 acre-feet between 1997 and 2006 as shown on Table 1.

Table 1. Estimated Water Demands in the Bradley Subarea for 1997 and 2006

GROUNDWATER DEMAND BY DEMAND TYPE FOR 1997 AND 2006 FOR THE BRADLEY SUBAREA							
Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	6,933	0	0	184	109	7,226
Estimated 1997 Demand	(acre-feet)	6,001	0	0	136	88	6,225
Difference (2006 less 1997)	(acre-feet)	932	0	0	48	21	1,001
2006 Demand Assumptions:	Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)						
1997 Demand Assumptions:	1997 Demands from Paso Robles Groundwater Basin Study (Fugro, 2002)						
	Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.						

Water demands in the North Gabilan Subarea met by groundwater have increased by total of about 250 acre-feet between 1997 and 2006 as shown on Table 2.

Table 2. Estimated Water Demands in the North Gabilan Subarea for 1997 and 2006

GROUNDWATER DEMAND BY DEMAND TYPE FOR 1997 AND 2006 FOR THE NORTH GABILAN SUBAREA							
Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	1,758	0	0	0	51	1,809
Estimated 1997 Demand	(acre-feet)	1,522	0	0	0	41	1,563
Difference (2006 less 1997)	(acre-feet)	236	0	0	0	10	246
2006 Demand Assumptions:	Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)						
1997 Demand Assumptions:	1997 Demands from Paso Robles Groundwater Basin Study (Fugro, 2002)						
	Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.						

Draft Basin Management Objectives

The different levels of BMOs were discussed at the workshop. As described above there is very little available information to support the development of very targeted BMOs. Based on the available information, the BMO for the Bradley Subarea and the North Gabilan Subarea are to maintain groundwater levels high. The lack of an extensive monitoring network in this part of the Basin will prevent more detailed analysis of this.

Potential Groundwater Management Activities

GMA 1: Continue monitoring and reporting on groundwater conditions: Continue and improve monitoring – look to add monitoring well near the SLO-Monterey county boundary between the Nacimiento River and the town of San Miguel

GMA 2: Consider reestablishing Cloudseeding Program: Consider benefits of re-establishing the cloud seeding program in the Nacimiento and San Antonio watersheds. Cloud seeding was conducted in the past by MCWRA, and is estimated to have increased outflow of Lake Nacimiento and San Antonio Reservoirs by about 20 percent.

Summary of Basin Management Objective Workshop
For the Creston Subarea

The draft Basin Management Objectives (BMOs) for groundwater levels in the Creston Subarea were discussed and developed by stakeholders of Creston Subarea at the Paso Robles Groundwater Basin Management Plan BMO Workshop held on April 19 at the City of Paso Robles City Council Chambers. The stakeholders from the Creston Subarea that attended the Workshop are listed below:

Name	Affiliation
Sue Luft	WRAC/Grower/RR
Karl Luft	Grower/RR
Sheila Lyons	Rural Resident
David Lyons	Rural Resident
Dana Merrill	Grower
Fritz Helzer	Grower
Claudia Engel	Creston AB
Pam Finley	Templeton AAG

Sue Luft recorded the information discussed by the Creston Subarea Stakeholders. The Creston Subarea Stakeholders generally reached consensus on most of the issues presented below.

Basin Management Objectives are intended to provide quantifiable and measureable targets so that progress towards improved groundwater management can be tracked. BMOs are being developed for subareas within the Paso Robles Groundwater Basin (Basin) to represent the differing groundwater conditions and necessary management activities.

Groundwater Management Activities (GMAs) are intended to identify the steps or actions taken to meet the BMOs. It should be recognized that both BMOs and GMAs should be evaluated and updated routinely (every few years) as additional information is collected, or in response to changing conditions.

Groundwater Levels in the Creston Subarea are affected by:

- Annual hydrologic conditions
- Changes in water demands that are met with groundwater

There are currently about 150 wells located within the limits of the Paso Robles Groundwater Basin that are monitored by the San Luis Obispo County Department of Public Works and the Monterey County Water Resources Agency. These wells are used to track the changes in groundwater level trends through time at a specific location, or across an area for a specific date.

The changes in groundwater levels in the Creston Subarea are currently recorded at 13 wells that are included in the groundwater monitoring network. Based on the groundwater level data collected in the Creston Subarea, there has been a general decline in groundwater levels observed and recorded at selected wells located throughout the subarea since the 1960s. The rate of decline changes through time in response to changing hydrologic conditions and changes in the amount of local groundwater pumping. The composite hydrograph of four wells (currently in the monitoring network) was selected to

represent the conditions in the subarea is shown on Figure 1. These wells will be used as an indicator to how groundwater levels in the subarea are changing over time.

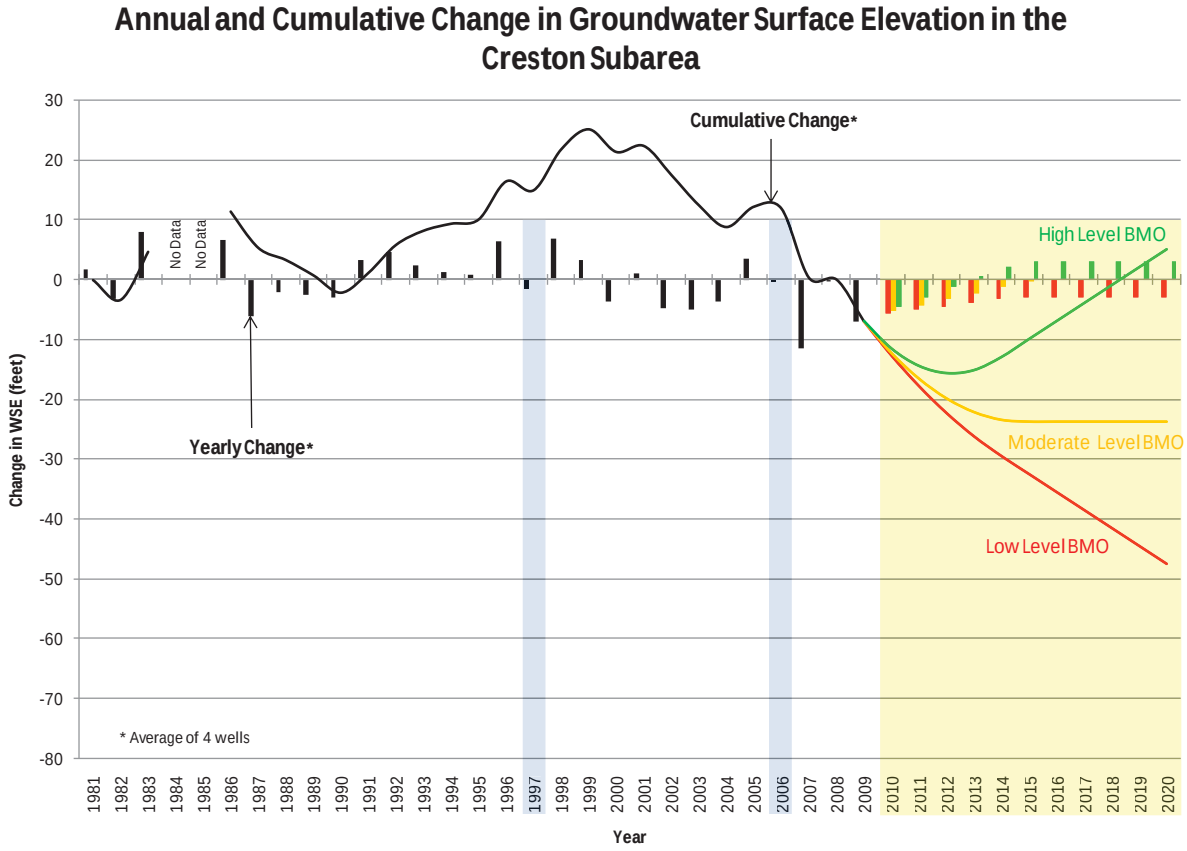

Figure 1. Composite Hydrograph of Four Selected Wells in the Creston Subarea

The average groundwater levels in the subarea appear to have peaked at about 1999. Since this time, groundwater levels have generally declined. This may be due in part to the increase in water demands between 1997 and 2006. During the 1997 to 2006 period, average groundwater levels have declined by less than five feet, but during the 2006 to 2009 period, the average groundwater levels declined by about 20 feet, so it appears that the increase in demands and the numerous dry years have contributed to the declining groundwater levels currently being experienced.

The 2010 to 2020 period included on Figure 1 shows potential range of changes in groundwater levels in the subarea under different levels of BMOs. Low level BMOs would be expected to result in a continuing decline of groundwater levels similar to those experienced during the 1997 to 2009 period. The moderate level BMO would eventually result in no change in groundwater levels (stabilized groundwater levels). The high level BMO would result in improvement of groundwater levels over time. These projected groundwater levels are intended to show the differences in groundwater levels based on target groundwater levels (BMOs) selected for the subarea, and the magnitude of the GMAs implemented. Additional analysis is needed to quantify the result (in terms of groundwater levels) due to the implementation of GMAs in the subarea.

Water demands in the Creston Subarea met by groundwater increased by about 1,800 acre-feet during the 1997 to 2006 period as shown on Table 1. This information does identify when this increase occurred, but it is likely to have contributed to the slight decline of groundwater levels during this period. These higher demands, along with drier conditions during the 2006 to 2009 period likely contributed to the increased rate of groundwater level decline (about seven feet per year) during this period.

Table 1. Estimated Water Demands in the Creston Subarea for 1997 and 2006

GROUNDWATER DEMAND BY DEMAND TYPE FOR 1997 AND 2006 FOR THE CRESTON SUBAREA							
Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	9,936	0	0	37	2,338	12,311
Estimated 1997 Demand	(acre-feet)	8,600	0	0	27	1,880	10,507
Difference (2006 less 1997)	(acre-feet)	1,336	0	0	10	458	1,804
2006 Demand Assumptions:	Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)						
1997 Demand Assumptions:	1997 Demands from Paso Robles Groundwater Basin Study (Fugro, 2002)						
	Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.						

Draft Basin Management Objectives

The Creston Subarea stakeholders determined that an acceptable draft BMOs for groundwater levels in the Creston Subarea would include stopping the current rate of decline experienced in the last 10 years, and stabilizing groundwater levels at about the 2009 level as presented in the composite hydrograph (average of four wells) in the next five to ten years.

Potential Groundwater Management Activities

The following Groundwater Management Activities (GMAs) were identified by the Creston Subarea Stakeholders to stabilize groundwater levels in the Creston Subarea. The potential benefit from these GMAs has not been quantified for the Creston Subarea (in terms of changes in groundwater levels), so it has not been determined if implementation of the GMAs will result in stabilized groundwater levels.

GMA 1: Increase monitoring and reporting on groundwater conditions: This GMA includes expanding the groundwater monitoring network in the Creston Subarea through the addition of new wells to the volunteer monitoring network. Additional wells would be needed in the northwest portion of the subarea near the Estrella Subarea where historic groundwater level decline has been the greatest.

Groundwater level measurements are currently taken by the County in the spring and fall of each year. Spring water levels will be used to track year-to-year changes and long-term trends in groundwater levels because they represent more stable conditions. Groundwater levels will be made available on a regular basis (semi-annually) within two months after most current readings, and will be included in the

Paso Robles Groundwater Basin Annual Report. This level of monitoring and reporting of groundwater levels should be sufficient for determining the effectiveness of the GMAs at this time. Additional monitoring and reporting may be needed at some future date.

While this GMA does not directly result in changes in groundwater levels, it will help communicate conditions to individuals and support implementation of groundwater management activities in the subarea.

The San Luis Obispo County Flood Control and Water Conservation District would likely be the lead entity of a cooperative group formed to collect, organize, and report on groundwater conditions in the Paso Robles Groundwater Basin on a regular basis.

GMA 2: Increase water conservation education and implementation: This GMA includes increasing the awareness of the impact of water conservation on reducing groundwater pumping. The effectiveness of the water conservation program will be difficult to verify for rural and agricultural areas without metering well production. The effectiveness of the GMA will be based on the changing behavior of individual water users. The effectiveness of this GMA will be evaluated on an annual basis. Some of the specific water conservation activities identified include:

- Agricultural Water Conservation
- Rural Residential Water Conservation
    - Landscape Water Use
    - Consider controls on non-agricultural ponds

Responsibility for implementing this GMA may include both the San Luis Obispo County Department of Planning and Building, and the San Luis Obispo County Flood Control and Water Conservation District.

GMA 3: Managing the growth and corresponding increase in water demands: This GMA includes identifying potential land use planning activities that may be used to reduce the rate of growth of rural residential development in the subarea. Throughout much of the Basin, land use planning responsibilities are the responsibility of the San Luis Obispo County Department of Planning and Building. Any policies established would be applied to the entire Basin, not just this subarea. This GMA may include:

- Building moratorium on lot splits and subdivisions
- No net increase in water use resulting from additional rural residential development

The San Luis Obispo County Department of Planning and Building would likely be responsible for implementing this GMA.

GMA 4: Preventing export of groundwater from the Basin: This GMA includes identifying potential activities that result in exporting groundwater from the Basin. At this time, additional information is necessary to quantify the occurrence of groundwater pumping for export from the Basin.

The San Luis Obispo County Flood Control and Water Conservation District and Department of Planning and Building would likely be the lead agencies responsible for implementing this GMA.

GMA 5: Consider storm water management opportunities to increase local groundwater recharge: This GMA includes evaluating the feasibility of recharging storm water runoff in the streams and creeks of the Basin. The potential benefit (in groundwater recharge) has not been evaluated for this GMA at this time.

The San Luis Obispo County Flood Control and Water Conservation District and Department of Planning and Building would likely be the lead agencies responsible for implementing this GMA.

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Summary of Basin Management Objective Workshop
For the Estrella Subarea

The draft Basin Management Objectives (BMOs) for groundwater levels in the Estrella Subarea were discussed and developed by stakeholders of Estrella Subarea at the Paso Robles Groundwater Basin Management Plan BMO Workshop held on April 19 at the City of Paso Robles City Council Chambers. The stakeholders from the Estrella Subarea that attended the Workshop are listed below:

Name	Affiliation
Joy Sprague	Rural Resident
Walter Heer	
Christopher Alakel	City of Paso Robles
Chuck Pritchard	Upper Salinas/Las Tablas Resource Conservation District (US/LT RCD)
Jerry Reaugh	Grower
Lisa Bodrogi	(Paso Robles Wine Country Alliance (PRWCA)
Joe Plummer	Grower
Debra Compton	Grower
Steve Carter	Grower
John Wallace	San Miguel CSD
Tom Zehnder	

Iris Priestaf recorded the information discussed by the Estrella Subarea Stakeholders. The Estrella Subarea Stakeholders generally reached consensus on the level of Basin Management Objectives, but did not reach consensus on the Groundwater Management Activities.

Basin Management Objectives are intended to provide quantifiable and measureable targets so that progress towards improved groundwater management can be tracked. BMOs are being developed for subareas within the Paso Robles Groundwater Basin (Basin) to represent the differing groundwater conditions and necessary management activities.

Groundwater Management Activities (GMAs) are intended to identify the steps or actions taken to meet the BMOs. It should be recognized that both BMOs and GMAs should be evaluated and updated routinely (every few years) as additional information is collected, or in response to changing conditions.

Groundwater Levels in the Estrella Subarea are affected by:

- Annual hydrologic conditions
- Changes in water demands that are met with groundwater

There are currently about 150 wells located within the limits of the Paso Robles Groundwater Basin that are monitored by the San Luis Obispo County Department of Public Works and the Monterey County Water Resources Agency. These wells are used to track the changes in groundwater level trends through time at a specific location, or across an area for a specific date.

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The changes in groundwater levels in the Estrella Subarea are currently recorded at 50 wells that are included in the groundwater monitoring network. Based on the groundwater level data collected in the Estrella Subarea, there has been a general decline in groundwater levels observed and recorded at selected wells located throughout the subarea since the 1960s. The rate of decline changes through time in response to changing hydrologic conditions and changes in the amount of local groundwater pumping. The composite hydrograph of six wells (currently in the monitoring network) was selected to represent the conditions in the subarea is shown on Figure 1. These wells will be used as an indicator to how groundwater levels in the subarea are changing over time.

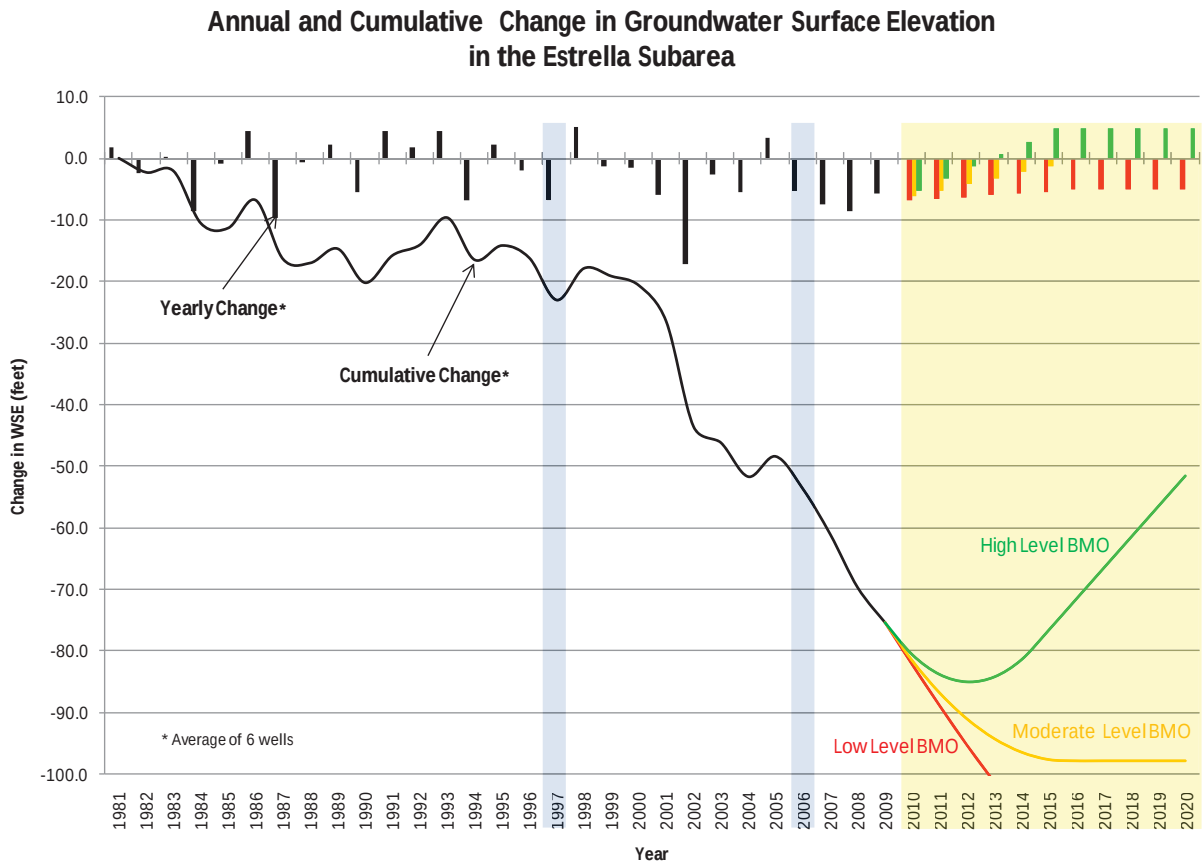

Figure 1. Composite Hydrograph of Six Selected Wells in the Estrella Subarea

Based on the composite hydrograph shown in Figure 1, the average groundwater levels in the Estrella Subarea have declined by about 20 feet between 1981 and 1997. Then, between 1997 and 2006 average groundwater levels have declined by an additional 30 feet. During this same period, water demands in the Estrella Subarea met by groundwater have increased by a total of about 6,300 acre-feet as shown on Table 1. Finally, from 2006 to 2009 the average groundwater levels declined by about 35 feet. During the 1981 to 2009 period, average groundwater levels in the Estrella Subarea declined by about 80 feet, in response to a combination of increasing in water demands that are met by groundwater and a series of dry years in the later years of the period.

The 2010 to 2020 period included on Figure 1 shows potential range of changes in groundwater levels in the subarea under different levels of BMOs. Low level BMOs would be expected to result in a continuing decline or groundwater levels similar to those experienced during the 1997 to 2009 period. The moderate level BMO would eventually result in no change in groundwater levels (stabilized groundwater levels). The high level BMO would result in improvement of groundwater levels over time. These projected groundwater levels are intended to show the differences in groundwater levels based on target groundwater levels (BMOs) selected for the subarea, and the magnitude of the GMAs implemented. Additional analysis is needed to quantify the result (in terms of groundwater levels) due to the implementation of GMAs in the subarea.

Water demands in the Estrella Subarea met by groundwater increased by about 6,300 acre-feet during the 1997 to 2006 period as shown on Table 1. This increase in demands contributed to the significant decline of groundwater levels during this period. These higher demands, along with drier conditions during the 2006 to 2009 period likely contributed to the increased rate of groundwater level decline (almost 10 feet per year) during this period.

Table 1. Estimated Water Demands in the Estrella Subarea for 1997 and 2006

GROUNDWATER DEMAND BY DEMAND TYPE FOR 1997 AND 2006 FOR THE ESTRELLA SUBAREA							
Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	23,111	3,930	0	1,603	5,433	34,077
Estimated 1997 Demand	(acre-feet)	20,004	2,137	0	1,186	4,368	27,695
Difference (2006 less 1997)	(acre-feet)	3,107	1,793	0	417	1,065	6,382
2006 Demand Assumptions:	Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)						
1997 Demand Assumptions:	1997 Demands from Paso Robles Groundwater Basin Study (Fugro, 2002)						
	Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.						
	1997 Municipal demand includes City of Paso Robles groundwater pumping from basin wells(1,911 acre-feet) and San Miguel (226 acre-feet)						
	Small community demands included in rural domestic demand						

Draft Basin Management Objectives

Three levels of BMOs were discussed by the Estrella Subarea stakeholders. There was consensus that groundwater level declines are a shared problem for the subarea, and that the severity of decline varies across the area. It was also identified that the proposed low-level BMO (essentially do-nothing) was unacceptable.

The medium level BMO of stabilizing groundwater levels was identified as a reasonable objective at this time, but there was concern about the cost and feasibility.

The high-level BMO of recovery of groundwater levels was identified as desirable by private domestic wells owner, but the group agreed that such an objective was over-reaching at this time.

Potential Groundwater Management Activities

The stakeholders reached consensus that there is no magic bullet that will solve the problem, but that the solution will likely involve a combination of activities such as additional water conservation, Nacimiento water supplies, a groundwater recharge program (e.g. using State Water Project or urban runoff), redistribution of pumping, and wastewater discharge/water recycling.

The following Groundwater Management Activities (GMAs) were identified by the Estrella Subarea Stakeholders to stabilize groundwater levels in the Estrella Subarea. The potential benefit from these GMAs has not been quantified for the Estrella Subarea (in terms of changes in groundwater levels), so it has not been determined if implementation of the GMAs will result in stabilized groundwater levels.

GMA 1: Increase data collection and monitoring and reporting on groundwater conditions: It was determined that there is enough information to know that there is a problem, however, additional and better information is needed to further understand the problem.

The stakeholders recognize that this GMA does not directly result in changes in groundwater levels, but will help communicate condition to individuals and support implementation of groundwater management activities in the subarea. It was recognized that additional private wells need to be made part of the County well network on a voluntary basis. This is particularly true in specific areas within the subarea currently lacking wells in the water level monitoring network.

GMA 2: Increase water conservation education and implementation: The stakeholders recognized that additional conservation is needed. Some stakeholders felt that the amount of savings that can be achieved is limited. Other stakeholders felt that additional conservation in the agricultural sector could play a significant role in reducing groundwater demand and achieving the BMO of stabilizing water levels. There were several discussions about the potential additional savings from conservation, but consensus could not be reached about the potential savings that could be achieved by the different water use categories (urban, agricultural, and rural). During the conversations each group stated that they believed there was limited opportunity for additional gains from conservation in their demand type, but believed additional conservation could be achieved in other demand types.

GMA 3: Nacimiento Project Water: The stakeholder reached consensus regarding the use of Nacimiento Project Water help alleviate the groundwater decline problem, but it was also recognized as not being the sole solution.

Issues Lacking Consensus

The two primary issues lacking consensus in the subarea was the degree to which additional conservation could be implemented for urban, agricultural, and rural uses.

The Paso Robles Groundwater Basin has largely centralized management because of a lack of water districts or local water agencies, so there was no consensus about the agency or organization that would have the responsibility for prioritizing and implementing the identified groundwater management activities.

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Summary of Basin Management Objective Workshop
For the San Juan Subarea

The draft Basin Management Objectives (BMOs) for groundwater levels in the San Juan Subarea of the Paso Robles Groundwater Basin (Basin) were discussed and developed by stakeholders of San Juan Subarea at the Paso Robles Groundwater Basin Management Plan BMO Workshop held on May 10 at the Shandon High School Gymnasium. The stakeholders from the San Juan Subarea that attended the Workshop are listed below:

Name	Affiliation
Amy Gillman	5th District Legislative Assistant
Steve Sinton	Shandon
Randy Diffenbaugh	Shandon Advisory Committee
Susan Litteral	Natural Resource Conservation Service
Doug Felipponi	SJV FET
Mary Russell	Shandon

Susan Litteral recorded the information discussed by the San Juan Stakeholders.

The San Juan Subarea Stakeholders generally reached consensus on the level of Basin Management Objectives and on the Groundwater Management Activities.

Basin Management Objectives are intended to provide quantifiable and measureable targets so that progress towards improved groundwater management can be tracked. BMOs are being developed for subareas within the Paso Robles Groundwater Basin (Basin) to represent the differing groundwater conditions and necessary management activities.

Groundwater Management Activities (GMAs) are intended to identify the steps or actions taken to meet the BMOs. It should be recognized that both BMOs and GMAs should be evaluated and updated routinely (every few years) as additional information is collected, or in response to changing conditions.

Groundwater Levels in the San Juan Subarea are affected by:

- Annual hydrologic conditions
- Changes in water demands that are met with groundwater

There are currently about 150 wells located within the limits of the Paso Robles Groundwater Basin that are monitored by the San Luis Obispo County Department of Public Works and the Monterey County Water Resources Agency. These wells are used to track the changes in groundwater level trends through time at a specific location, or across an area for a specific date.

The changes in groundwater levels in the San Juan Subarea are currently recorded at 10 wells that are included in the groundwater monitoring network. Overall, groundwater levels have been fairly stable in the San Juan Subarea. The composite hydrograph of four wells (currently in the monitoring network) was selected to represent the conditions in the subarea is shown on Figure 1 for the 1981 to 2009

period. These wells will be used as an indicator to how groundwater levels in the subarea are changing over time.

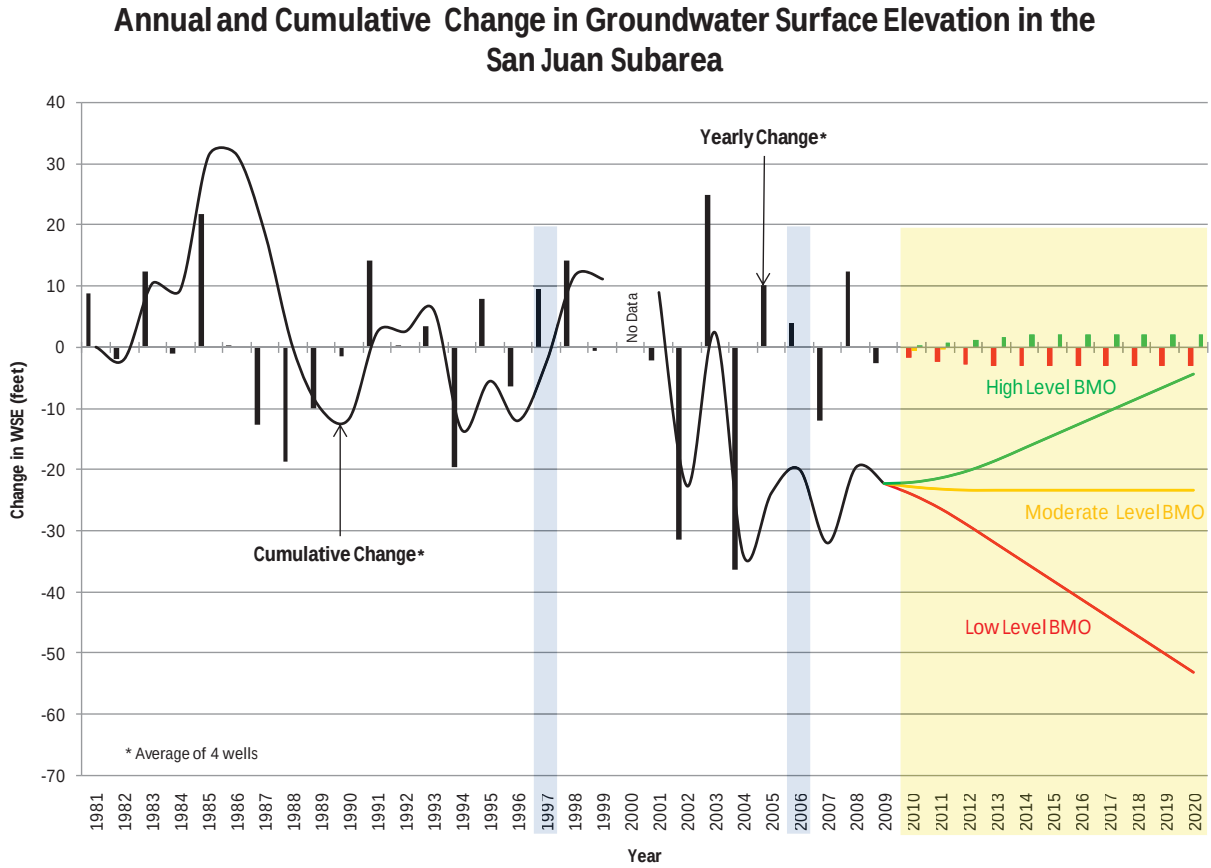

Figure 1. Composite Hydrograph of Four Selected Wells in the San Juan Subarea

Based on the composite hydrograph shown in Figure 1, the San Juan Subarea shows highly variable annual changes in groundwater levels. It appears that groundwater levels in the San Juan Subarea respond quickly to changes in hydrologic conditions, with average groundwater levels increasing or decreasing by as much as 35 feet in a single year.

During the 1981 and 1997 period, average groundwater levels changed considerably on a year-to-year basis, but there was no net significant difference in the cumulative groundwater levels at the end of the 16-year period. During the 1997 and 2006 period, the average groundwater levels in the San Juan Subarea declined by about 20 feet. Finally, during the 2006 to 2009 period, the average groundwater levels declined slightly (less than 5 feet). Overall, during the 1981 to 2009 period, average groundwater levels in the San Juan Subarea declined by about 25 feet.

The 2010 to 2020 period included on Figure 1 shows potential range of changes in groundwater levels in the subarea under different levels of BMOs. Low level BMOs would be expected to result in a continuing decline or groundwater levels similar to those experienced during the 1997 to 2009 period. The moderate level BMO would eventually result in no change in groundwater levels (stabilized groundwater

levels). The high level BMO would result in improvement of groundwater levels over time. These projected groundwater levels are intended to show the differences in groundwater levels based on target groundwater levels (BMOs) selected for the subarea, and the magnitude of the GMAs implemented. Additional analysis is needed to quantify the result (in terms of groundwater levels) due to the implementation of GMAs in the subarea.

The stakeholders mentioned that the area is primarily planted with field crops, and very few permanent crops. The statement was made that the amount of annual plantings are based in part on the depth to groundwater, because greater depth to groundwater increases pumping costs, at some point it will become uneconomical to grow some crops. This pattern of behavior (not planting some crops when groundwater levels are low) may contribute to the recovery response in groundwater levels, and preventing long-term groundwater level declines in the subarea.

Water demands in the San Juan Subarea met by groundwater have increased by a total of about 740 acre-feet between 1997 and 2006 as shown on Table 1. Looking at just these two single years of estimated water demand data may not provide a clear picture of the annual variation in agricultural water demand in the subarea.

Table 1. Estimated Water Demands in the San Juan Subarea for 1997 and 2006

Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	5,347	0	0	0	105	5,452
Estimated 1997 Demand	(acre-feet)	4,628	0	0	0	84	4,712
Difference (2006 less 1997)	(acre-feet)	719	0	0	0	21	740
2006 Demand Assumptions:	Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)						
1997 Demand Assumptions:	1997 Demands from Paso Robles Groundwater Basin Study (Fugro, 2002)						
	Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.						

Draft Basin Management Objectives

The different levels of BMOs were discussed at the workshop. There was consensus among the stakeholders that groundwater levels fluctuate considerably, but that there was no real concern of long-term declining groundwater levels at this time. Because the subarea experiences periods of rising and falling groundwater levels, the stakeholders expect the cumulative change in average groundwater levels to fluctuate over time, but return to zero net change in groundwater levels (no change from 1981 levels) without implementation of large scale groundwater management activities.

Potential Groundwater Management Activities

Because of the nature of the subarea, and pattern of groundwater use, this subarea may not have the same need for Groundwater Management Activities (GMAs) as other subareas in the

Basin. The following GMA was identified by the San Juan Subarea Stakeholders to stabilize groundwater levels in the San Juan Subarea.

GMA 1: Continue monitoring and reporting on groundwater conditions: The stakeholders suggest continuing the groundwater level monitoring and reporting program. The existing monitoring network provides reasonable coverage for the subarea at this time based upon the current groundwater level conditions. Additional monitoring wells could be added, but are not considered as important as continuing to actively monitoring and reporting on groundwater levels to extend the historical period of record.

DRAFT

Summary of Basin Management Objective Workshop
For the Shandon Subarea

The draft Basin Management Objectives (BMOs) for groundwater levels in the Shandon Subarea of the Paso Robles Groundwater Basin were discussed and developed by stakeholders of the Shandon Subarea at the Paso Robles Groundwater Basin Management Plan BMO Workshop held on May 10 at the Shandon High School Gymnasium. The stakeholders from the Shandon Subarea that attended the Workshop are listed below:

Name	Affiliation
Mike Clay	Red Cedar Vineyard
Dennis Bowman	Green River Mutual Water
Greg Jaeger (South Gabilan)	Rural Resident
Sydney Wattles	Shandon Home-Owner
Keith Larson	City of Paso Robles
Frank Mecham	SLO County
Kate Twisselman	Shandon Advisory Committee
Raymond Twisselman	Shandon Resident
Les Diffenbaugh	Shandon Resident
Fritz Helzer	Shandon Hills Vineyard

Courtney Howard (San Luis Obispo County Public Works Department Staff) recorded the information discussed by the Shandon Subarea Stakeholders. One stakeholder from the South Gabilan Subarea attended the workshop and participated in the discussions of the Shandon Subarea stakeholders.

While not all of the Shandon Subarea stakeholders are experiencing the same magnitude of groundwater level decline or type of groundwater quality deterioration, they generally reached consensus on the level of Basin Management Objectives, and some of the Groundwater Management Activities. One of the biggest concerns was the cost of the GMAs identified, and their overall cost effectiveness at improving groundwater levels in the subarea.

Basin Management Objectives are intended to provide quantifiable and measureable targets so that progress towards improved groundwater management can be tracked. BMOs are being developed for subareas within the Paso Robles Groundwater Basin (Basin) to represent the differing groundwater conditions and necessary management activities.

Groundwater Management Activities (GMAs) are intended to identify the steps or actions taken to meet the BMOs. It should be recognized that both BMOs and GMAs should be evaluated and updated routinely (every few years) as additional information is collected, or in response to changing conditions.

Groundwater Levels in the Shandon Subarea are affected by:

- Annual hydrologic conditions
- Changes in water demands that are met with groundwater

There are currently about 150 wells located within the limits of the Paso Robles Groundwater Basin that are monitored by the San Luis Obispo County Department of Public Works and the Monterey County Water Resources Agency. These wells are used to track the changes in groundwater level trends through time at a specific location, or across an area for a specific date.

The changes in groundwater levels in the Shandon Subarea are currently recorded at 18 wells that are included in the groundwater monitoring network. Based on the groundwater level data collected in the Shandon Subarea, there has been a general decline in groundwater levels observed and recorded at selected wells located throughout the subarea since the 1960s. The rate of decline changes through time in response to changing hydrologic conditions and changes in the amount of local groundwater pumping. The composite hydrograph of four wells (currently in the monitoring network) was selected to represent the conditions in the subarea (shown on Figure 1) for the 1981 to 2009 period. These wells will be used as an indicator to how groundwater levels in the subarea are changing over time.

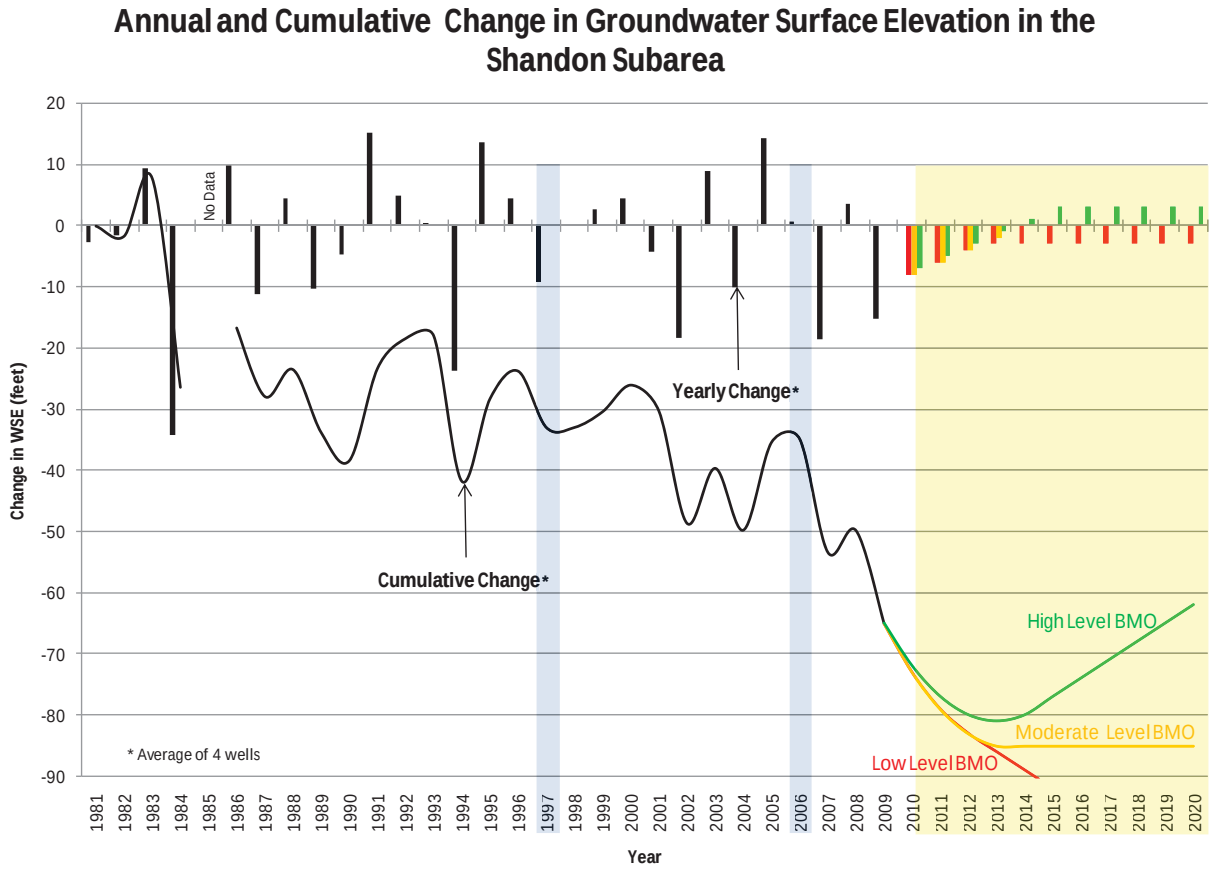

Figure 1. Composite Hydrograph of Four Selected Wells in the Shandon Subarea

Based on the composite hydrograph shown in Figure 1, the Shandon Subarea shows a wide range of annual changes in groundwater levels, with a general trend of declining groundwater levels.

During the 1981 to 1997 period, average groundwater levels in the Shandon Subarea have declined by about 33 feet. During the 1997 to 2006 period, average groundwater levels fluctuated annually, but resulted in very little net decline (about 2 feet) compared to 1997 levels. Finally, from 2006 to 2009 period, the average groundwater levels declined by about 30 feet. Overall, during the 1981 to 2009 period (28 years), average groundwater levels in the Shandon Subarea declined by about 65 feet (about 2.3 feet per year), in response to a combination of increasing in water demands that are met by groundwater, and in the later years of the period, a series of dry years.

The 2010 to 2020 period included on Figure 1 shows potential range of changes in groundwater levels in the subarea under different levels of BMOs. Low level BMOs would be expected to result in a continuing decline or groundwater levels similar to those experienced during the 1997 to 2009 period. The moderate level BMO would eventually result in no change in groundwater levels (stabilized groundwater levels). The high level BMO would result in improvement of groundwater levels over time. These projected groundwater levels are intended to show the differences in groundwater levels based on target groundwater levels (BMOs) selected for the subarea, and the magnitude of the GMAs implemented. Additional analysis is needed to quantify the result (in terms of groundwater levels) due to the implementation of GMAs in the subarea.

Water demands in the Shandon Subarea met by groundwater increased by about 1,600 acre-feet during the 1997 to 2006 period as shown on Table 1. This increase in demands may have contributed to the slight decline of groundwater levels during this period. These higher demands, along with drier conditions during the 2006 to 2009 period likely contributed to the increased rate of groundwater level decline (about 10 feet per year) during this period.

Table 1. Estimated Water Demands in the Shandon Subarea for 1997 and 2006

GROUNDWATER DEMAND BY DEMAND TYPE FOR 1997 AND 2006 FOR THE SHANDON SUBAREA							
Groundwater Demand		Demand Type					
		Agricultural	Municipal	Small Community	Small Commercial	Rural Domestic	TOTAL
2006 Demand	(acre-feet)	9,896	0	0	69	1,205	11,170
Estimated 1997 Demand	(acre-feet)	8,566	0	0	51	969	9,586
Difference (2006 less 1997)	(acre-feet)	1,330	0	0	18	236	1,584
2006 Demand Assumptions:	Based on Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006 (Todd, May 2009)						
1997 Demand Assumptions:	1997 Demands from Paso Robles Groundwater Basin Study (Fugro, 2002)						
	Distribution of agricultural demands based on crop acreages from 1997 DWR land use survey for San Luis Obispo County.						

Draft Basin Management Objectives

The stakeholders were initially concerned that the only way to stop the declining groundwater levels was to force people to stop pumping. Initially, the discussions of the group suggested a 'survival of the fittest' approach to groundwater pumping where only those with the deepest wells and the ability to afford pumping would continue to pump as costs increased. The others would be put out of business or be forced to make changes to their water use requirements.

After continued discussions, it was generally agreed that stabilizing groundwater levels was an appropriate objective at this time, but there is a concern about the cost and feasibility of stabilizing groundwater levels.

Potential Groundwater Management Activities

The stakeholders reached consensus that there was no single activity that would solve the problem, but that the solution will likely involve a combination of activities. The following Groundwater Management Activities (GMAs) were identified by the Shandon Subarea stakeholders to stabilize groundwater levels in the Shandon Subarea. The potential benefit from these GMAs has not been quantified for the Shandon Subarea (in terms of changes in groundwater levels), so it has not been determined if implementation of the GMAs will result in stabilized groundwater levels.

GMA 1: Groundwater Recharge and Banking Programs: The discussions did not focus on the details of this project or the approach, but did identify potential groundwater recharge or banking of either imported supplies or from storm water runoff as potential sources of groundwater recharge. One potential project that was discussed was an inflatable dam project such as was done along the Salinas River in Northern Monterey County. No additional details were provided on that potential project.

GMA 2: State Water Project supplies for Shandon: The community of Shandon has not used its 100 acre-feet of State Water Project water (SWP) to date. This project would include tying in to the Coastal Branch were it passes through Shandon to access the 100 acre-feet of supply. SWP supplies on the Coastal Branch are treated at the Polonio Pass Water Treatment Plant. This project would reduce municipal groundwater pumping in the Shandon area by the amount delivered from the SWP, thereby reducing groundwater pumping.

An alternative of this GMA would be to pursue additional SWP supplies that could also be delivered to Shandon. San Luis Obispo County has a contract allocation to additional SWP supplies that it has not used, and is not currently using. These supplies could be a potential source of water to the area. Additional capacity in Phase II of the Coastal Branch would be needed to deliver water in excess of the 100 acre-feet supply currently contracted to Shandon by the County. An investigation regarding the additional capacity of the Coastal Branch is currently being pursued by the District.

GMA 3: Formation of Irrigation District or Water District: The discussion focused on the potential need to form an irrigation district or water district to import surface water into the Paso Robles Groundwater Basin. Irrigation Districts/Water Districts are often formed to pursue large projects that benefit a larger group of water users. Such a district may be formed to

pursue a groundwater recharge or water banking project that would rely on imported surface water.

GMA 4: Increase water conservation education and implementation: The stakeholders recognized that additional conservation may result in a water savings, but were not sure if it would be cost effective. There was no objection to promoting conservation, and some discussions explored different conservation methods (such as alternative frost-control measures) since most growing operations are already on drip, and landscaping in Shandon is generally modest.

GMA 5: Precipitation Enhancement: This was brought up for discussion, but it was unclear whether this project would work for the Shandon area.

DRAFT

Appendix E Groundwater Elevation Monitoring Program

Paso Robles Groundwater Basin Management Plan

Groundwater Level Monitoring Network Plan for the Paso Robles Groundwater Basin

Paso Robles Groundwater Basin – Groundwater Advisory Committee

February 2011

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Abbreviations and Acronyms

Basin	Paso Robles Groundwater Basin
BMOs	Basin Management Objectives
City	City of Paso Robles
County	San Luis Obispo County
CSAs	County Service Areas
District	San Luis Obispo County Flood Control and Water Conservation District
DPW	County Department of Public Works
DWR	California Department of Water Resources
GAC	Groundwater Advisory Committee
IRWMP	Integrated Regional Water Management Plan
M&I	Municipal and Industrial
MCWRA	Monterey County Water Resources Agency
State	State of California
TDS	total dissolved solids
UWMP	Urban Water Management Plan
WRAC	Water Resources Advisory Committee

1 Introduction

1.1 Introduction

The Paso Robles Groundwater Basin (Basin) is located in northern San Luis Obispo County (County) and southern Monterey County and was described in the 1958 California Department of Water Resources (DWR) Bulletin 118, San Luis Obispo County Investigation. As part of the efforts to map the groundwater basins in the State of California (State) presented in Bulletin 118, DWR identified the Paso Robles Area Groundwater Subbasin of the Salinas Valley Groundwater Basin and designated it as Basin Number 3-4.06. The Basin boundary was later updated in the Paso Robles Groundwater Basin Study (2002) and is shown on Figure 1-1.

The Basin encompasses an area of approximately 505,000 acres (790 square miles). The Basin ranges from the Garden Farms area south of Atascadero to San Ardo in Monterey County, and from the Highway 101 corridor east to Shandon (Figure 1-1). Most of the Basin is hydraulically connected by thick sedimentary sections. The Basin is divided into smaller subareas based on water quality, source of recharge, groundwater movement, and the contours of the base of permeable sediments.

The Atascadero Subbasin is defined as that portion of the Basin west of the Rinconada fault. Between Atascadero and Creston, the Rinconada fault juxtaposes less permeable Monterey Formation rocks with the Paso Robles Formation basin sediments. South of the City of Paso Robles, the Paso Robles Formation is found on both sides of the Rinconada fault; however, the fault zone is believed to form a leaky barrier that restricts flow from the Atascadero Subbasin to the main part of the Basin. As a result of this, the Atascadero Subbasin is a hydrologically distinct subbasin within the Basin. The Rinconada Fault does not act as a hydraulic barrier to groundwater flow in the Salinas River Alluvium. As such, groundwater flow in the Alluvium is continuous along the stretch of the Salinas River that traverses the entire Basin. The area encompasses the Salinas River corridor area south of Paso Robles and includes the communities of Garden Farms, Atascadero, and Templeton.

The Basin was subdivided into subareas in the Phase I Report (Fugro, 2002) as a practical approach to organize the 790 square mile Basin into smaller informal areas (see Figure 1-1) and listed below.

1. Atascadero Subbasin
2. Creston Subarea
3. San Juan Subarea
4. Estrella Subarea
5. Shandon Subarea

6. North Gabilan Subarea
7. South Gabilan Subarea
8. Bradley Subarea

Over the past decade, the San Luis Obispo County Flood Control and Water Conservation District (District) and the City of Paso Robles (City) have worked with other pumpers to develop a more organized approach to groundwater management in the Basin. The preparation of the Paso Robles Basin Groundwater Management Plan (Plan) is one of the current activities to improve groundwater management.

The Plan was prepared coincident with the preparation of the Resource Capacity Study as well as other ongoing studies to develop a stakeholder-driven voluntary plan to provide a framework for future groundwater management activities. This project was funded by a grant from the Local Groundwater Assistance Act of 2000 (California Water Cost Section 10795 et seq) to provide grants to public agencies to conduct groundwater studies or to carry out groundwater monitoring and management activities. Local Groundwater Assistance Grants (AB303) are awarded by the California Department of Water Resources (DWR). Funding was available in 2007-2008 for AB303 grants.

Groundwater management requires groundwater level and other data collected and analyzed on a routine basis (typically annually) to establish the current conditions of the groundwater basin. This information is tracked and reported to agencies, interested parties, and stakeholders.

There are currently about 160 wells located within the limits of the Paso Robles Basin that are monitored by the San Luis Obispo County Department of Public Works, cooperating agencies, and the Monterey County Water Resources Agency.

The goals of the groundwater level monitoring and reporting program in the Paso Robles Basin include:

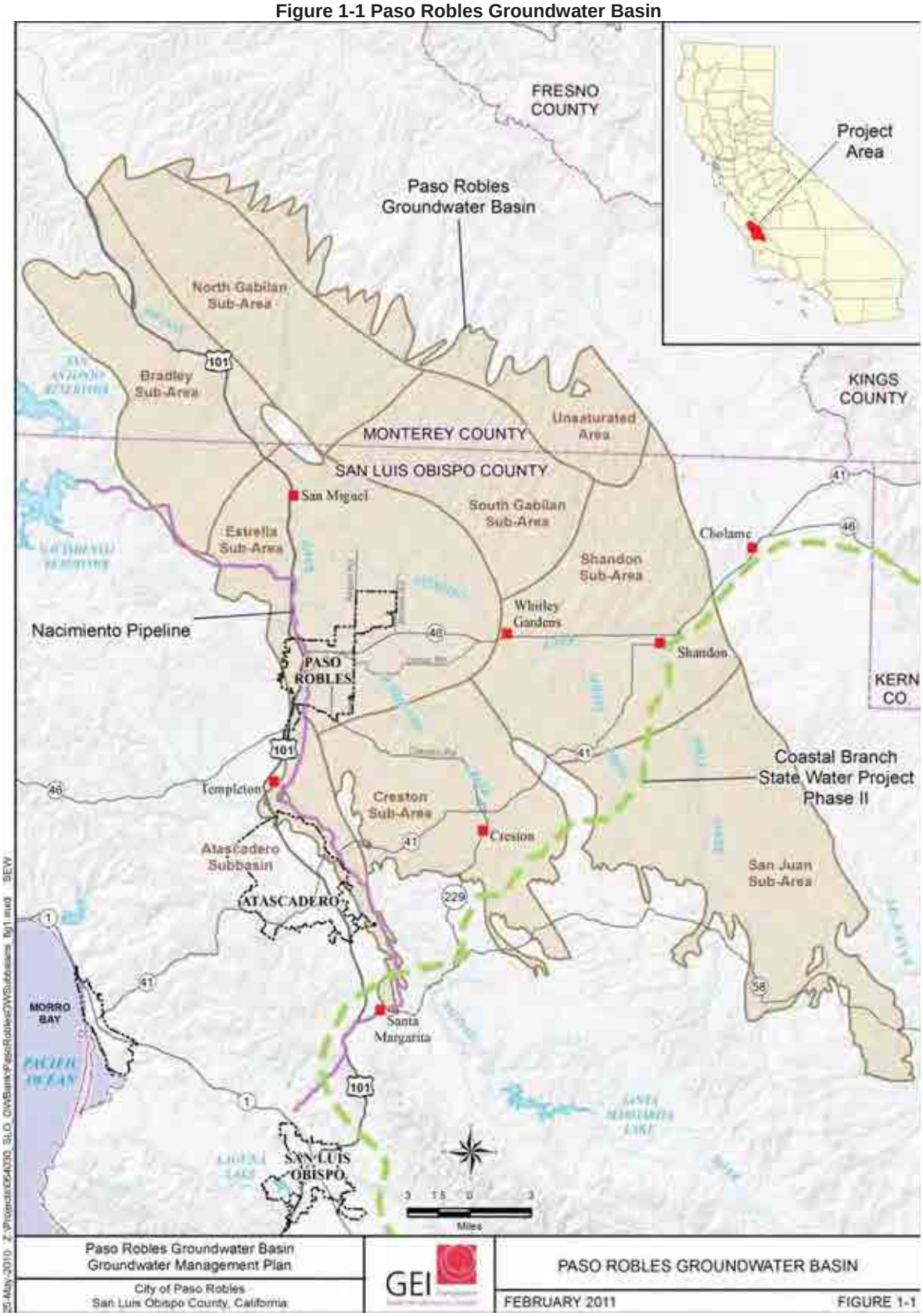
- Assessing groundwater elevations on an annual basis including trends, conditions, and adequacy of the groundwater level monitoring network.
- Preparing and distributing annual groundwater level monitoring reports to the public and public officials.
- Developing an outreach program to obtain groundwater level data from private pumpers and private well owners in the Basin.
- Coordinating with local, state, and federal agencies to develop better information on groundwater level monitoring and comply with current monitoring and report requirements such as California Statewide Groundwater Elevation Monitoring (CASGEMs) Program.

There are gaps in the monitoring network both laterally and vertically which, if filled, would improve the ability of groundwater users and managers in the Basin to fully understand the state of the groundwater conditions.

This Groundwater Level Monitoring Network Plan was prepared as part of the Paso Robles Groundwater Basin Management Plan to identify and document the groundwater level monitoring network and potential actions to improve the network. This Groundwater Level Monitoring Network is organized as follows:

- Section 1 – Introduction
- Section 2 – Existing Monitoring Network
- Section 3 – Monitoring Protocols
- Section 4 – Recommendations for Improving Groundwater Level Monitoring Network
- Section 5 – References

Figure 1-1 Paso Robles Groundwater Basin



2 Existing Monitoring Network

In the Paso Robles Basin, the County has been monitoring groundwater levels on a semi-annual basis (spring and fall) for more than 50 years to support general planning and engineering purposes.

The monitoring takes place from a voluntary monitoring network of production wells. The voluntary monitoring network has changed over time as wells have been lost, or new wells have been added to the network. In 2003, an evaluation of the monitoring network in the Paso Robles Basin was completed by Cleath and Associates to evaluate the efficiency and effectiveness of the County's Monitoring Program for wells located in the Basin. In 2008, this analysis was updated by Cleath & Associates for San Luis Obispo County's county-wide monitoring program, and included changes in the Paso Robles Basin since the 2003 report.

These reports are used as the basis for describing the groundwater level monitoring network in the Paso Robles Basin. The Paso Robles Basin monitoring network should include wells that produce water from either the alluvial aquifers or the Paso Robles Formation aquifers.

- **Shallow Aquifer Monitoring** - The report identified the importance of including monitoring wells in the shallow alluvial aquifers of the Salinas River, Estrella River, Huer Huero Creek, and San Juan Creek. If possible, these wells should be located near stream gages to support future analysis of stream recharge.

- **Paso Robles Formation Monitoring** - The Paso Robles Formation includes various aquifer types including shallow-unconfined zones, lower-confined zones (pressure zones) and thermal aquifer zones. Monitoring wells should be included in the monitoring network which taps each of these different aquifer zones.

The wells included in the monitoring network are selected based on aquifer definition and uniform areal distribution. There are approximately 159 wells in the current monitoring program (see Figure 2-1), County Public Works employees monitor 100 wells, and 57 wells are monitored by local municipal water company employees (who forward the data to the County's Public Works Department for inclusion in the monitoring program database). Additionally, three wells are located in Monterey County and are monitored by the Monterey County Water Resources Agency.

Table 2-1 lists the number of monitoring wells in each subarea, with more wells in the areas of the greatest population density (in the urban areas) and the largest developed agricultural areas. In general, many of the wells in the Atascadero Subbasin and the Estrella Subarea are associated with urban land uses. In the Creston Subarea and the rest of the Basin, monitoring wells are located adjacent to agricultural lands.

During the 2008 Monitoring Program Evaluation, criteria were developed to improve the monitoring network by identifying existing wells to add to the monitoring program, and identify existing wells to be eliminated from the monitoring program. The general criteria for selecting wells for inclusion in the monitoring network included:

- Wells included in the program should be located geographically throughout the Basin and vertically throughout the aquifer system to provide groundwater level data that represents natural static water levels that are not influenced by transient conditions.
- Selected wells should not pump frequently or be within 1,000 feet of a high producing well or wells tapping the same aquifer.
- Two wells that tap different aquifers may be located in close proximity to each other without producing redundant monitoring data.
- Because younger alluvial deposits contain aquifers separated from deeper aquifers, and the Paso Robles Formation typically contains multiple aquifers, there should be separate program wells in a particular subarea that tap these various aquifers.
- The various Paso Robles Formation aquifer types to be represented by program wells include shallow-unconfined zones, lower-confined (pressure) zones, and in some locations thermal aquifer zones.
- Monitoring well distribution should be based on population density and projected population growth, and on current and projected land use because of the greater well pumping impacts in these areas.

Groundwater level data is currently recorded in bound field books containing card files from each well. Each well card file includes the well name, a location sketch, description of the well head and access, water level measurement and reference point, depth to water by date, observer's initials and comments. Well construction reports should be obtained for all wells included in the monitoring network that would include much of this information.

During development of the Paso Robles Groundwater Management Plan, recent land use data was collected to compare the current land use to the existing monitoring network. This identified additional gaps in the monitoring network.

These gaps are located adjacent to areas currently experiencing declining groundwater levels, or are in areas where limited or no water level data is available. Figure 2-2 shows the locations of the wells to be added to the existing groundwater monitoring network (listed on Table 2-1) and areas that need additional monitoring where existing wells have not been identified.

Some of these areas include:

- Around the City of Paso Robles
- Creston Road Area
- Union Road Area
- Highway 46 west of Whitley Gardens
- Jardine Road Area

- Airport Road- Highway 101
- Highway 46 east of Whitley Gardens
- Creston Area
- Shandon Area
- Highway 41 south of Shandon
- North of San Miguel
- East of San Miguel

Table 2-1. Monitoring Program in the Paso Robles Groundwater Basin

Groundwater Subarea	Wells Currently in Program	Wells Added to Program	Wells Dropped From Program	Wells In Updated Program
Atascadero Subbasin	51	2	0	53
Bradley	0	1	0	1
Creston	17	6	2	21
Estrella	50	11	5	56
Gabilan (North and South)	1	0	0	1
San Juan	16	10	2	24
Shandon	24	5	4	25
TOTAL	**159**	**35**	**13**	**181**

Figure 2-1 Existing Well Monitoring Network

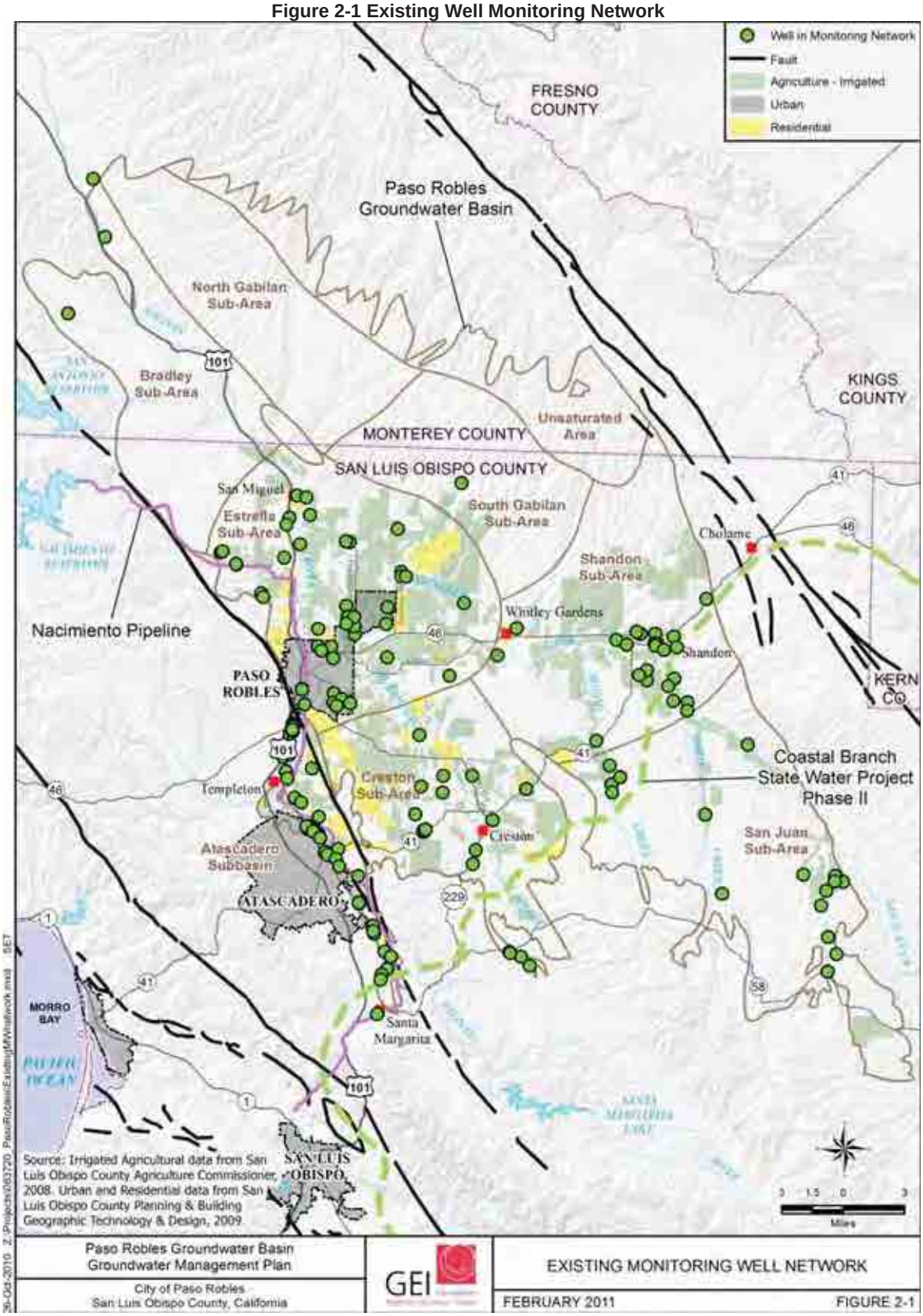
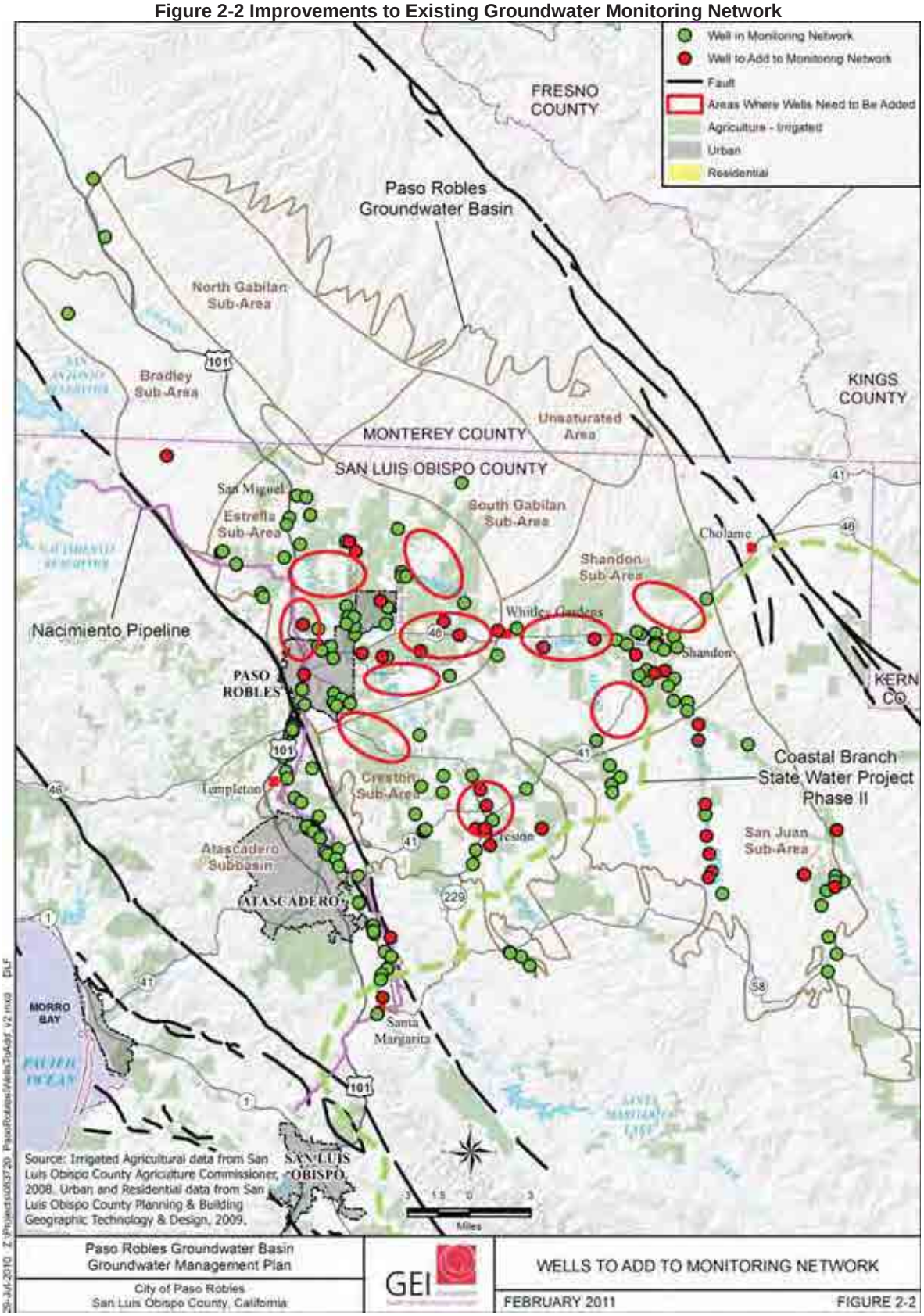


Figure 2-2 Improvements to Existing Groundwater Monitoring Network



3 Monitoring Protocols

The following is the standard operating procedure used by the County for the determination of groundwater surface elevations for wells in the Paso Robles Groundwater Basin monitoring network. These procedures may be varied or changed as required, depending on the site conditions, and equipment limitations.

In all instances, the actual procedures employed will be documented and described on the Groundwater Level Form. The water level measurements are used to construct water table or potentiometric surface maps and to determine flow direction as well as other aquifer characteristics.

Groundwater levels shall be measured in all wells on a semi-annual basis. If possible, sampling personnel should make groundwater level measurements in the same week but at no time should the measurements be taken over a period exceeding two-weeks.

3.1 Preparation for Field Work

Prior to collecting groundwater levels and before going to the field, sampling personnel shall clean, maintain, and test the water level sounder.

The sampling personnel will assemble the following equipment and supplies:

- Copies of Groundwater Level Form on waterproof paper
- Copies of well cards for wells being monitored
- Copy Monitoring Network Location map
- Electrical water level sounder
- Measuring Tape with gradations in tenths and hundredths of feet.
- Ballpoint pen (waterproof) and clipboard
- Paper towels
- Bleach
- Spray bottles
- Distilled water

During use of a water level sounder, it is possible for the cable to become stretched or shortened because of tangles and obstructions in wells. Before each monitoring event, the water level sounder shall be calibrated by laying it out and comparing it with a steel tape and the results documented. When calibration measurements show that the measurements are greater than 0.10 feet off in 100 feet, the cable shall be replaced.

Measurement locations will be identified and appropriate accommodations and permissions for site access will be made.

3.2 Monitoring Procedures

The following procedures shall be used to measure the depth to water at each designated monitoring well.

3.2.1 Verify the Reference Point

Distance above or below ground level to the reference point (RP) at which depth to water in the well is measured, i.e. TOC (Top of Casing). Make sure the measurement is equal to the one listed on the first well card for each well. If there is a difference in the distance, make a note in the remarks and correct the data on the front of the card.

3.2.2 Recording of Measurements

Each well has been assigned a unique identification number and a common name. The Groundwater Level Form will be used to record all groundwater level measurements and other information regarding well while in the field.

Groundwater level measurements will be measured to the nearest 0.01 foot. To obtain a depth to water measurement, the electric sounder cable will be lowered slowly into the well through the access port until the sounder indicates submergence by a beeping sound and/or light, depending on the type of sounder being used. At this point, the sampling personnel will note the depth to water from the reference point. The depth shall be confirmed by lifting the sounder above the water surface by about 2 to 3 feet and then re-measuring the depth to water. If the depth remains constant, the depth-to-water shall be recorded on the Groundwater Level Form, along with the time and date of the measurement. If the depth changes, the sampling personnel shall indicate that on the form, as well as the variable nature of the measurement and its possible cause (e.g., bouncing, recovering water levels, oil on water surface). The following measurements will be recorded:

- **Depth from Reference Point**: Total distance from the reference point to the top of the water.
- **Reference Point Distance**: Total distance from ground to reference point. If the reference point is above the ground surface, the reference point distance is a positive value. If the reference point is below the ground surface, the reference point distance is a negative value.
- **Depth to Water**: Total distance from the ground surface to the top of the water. It is calculated as the 'Depth from Reference Point' less the 'Reference Point Distance'.
- **Obs. Init.**: Initials of sampling personnel
- **Remarks**: Any special remarks will go in this area.

3.2.3 Static Measurement Verification

The following procedure will be used to verify if a well has or has not been recently been pumping (for example, the difference it greater than 0.02 feet or there are other indicators of recent pumping). Once the depth of the water is measured, pull the end of the sounder up ½ inch and wait about 5 minutes to see if a signal is acquired. If it does re-acquire a signal, pull it up ½ inch again and wait to see if a signal is acquired. If it is reacquired, make a note in the remarks section "Well rebounding". If the pump is hot or the water pipe is cool, a note should be made in the remarks section.

If sampling personnel will be working in the area and it won't be an inconvenience they may check at a later time to see if the well isn't pumping. "Well Pumping" will be written on the data card.

3.2.4 Well Actively Pumping

If a well is actively pumping, unless it is stated on the well's first page, the measurement will not be taken.

3.2.5 Maintenance and Cleaning of Equipment

Prior to obtaining the water level measurement at each well and between each well site, the bottom 10 feet of the electric sounder cable shall be rinsed in a solution of sodium hypochlorite (liquid bleach) and distilled water. The solution shall consist of bleach and distilled water in a one-tablespoon-to-one-quart ratio (a concentration of about 200 parts per million chlorine is desirable). The sounder shall then be rinsed thoroughly three times with distilled water and allowed to air-dry. Thorough cleaning of equipment is necessary to avoid any possibility of cross-contamination and transport of bacteria between wells.

3.2.6 Discontinuing Records

If there is a well that has not been monitored during the last three monitoring periods, i.e. could not find, no opening in top, removed, make a special note and this well will be considered for removal from the network.

3.3 Quality Assurance

In the field, the following general quality assurance/quality control (QA/QC) procedures apply:

1. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified.

2. Each well should be tested at least twice in order to compare results. If results do not agree to within 0.02 feet, a third measurement should be taken and the readings averaged. Notes about the inconsistent measurements and their possible cause should be made on the Groundwater Level Form.

3. Results should be compared to historical measurements while in the field and significant discrepancies noted and resolved if possible.

4. Wells for which no or questionable measurements are obtained need to be documented by the sampling personnel in the remarks section of the Groundwater Level Form.

After field personnel have completed their work, the data shall be entered into an electronic spreadsheet or database. The groundwater level measurements shall be proofed for accuracy by a second person within five days of obtaining the measurements. Should a measurement appear suspicious, a confirmation reading shall be obtained.

4 Recommendations for Improving the Groundwater Level Monitoring Network

This section identifies some of the activities related to maintaining and improving the groundwater level monitoring network. Several different factors may contribute to the improvements to the monitoring network, which may include the following:

- Recent groundwater monitoring legislation
- Improvements to the existing voluntary monitoring network
- Improvements to the data collected from wells in the existing monitoring network
- Development of a dedicated monitoring network to supplement the existing voluntary monitoring network
- Recommendations from the Resource Capacity Study regarding groundwater monitoring

Each of these are described below.

4.1 Complying with New Groundwater Monitoring Legislation

Future groundwater elevation monitoring and reporting will need to comply with the California Statewide Groundwater Elevations Monitoring Program (CASGEMs). This legislation, passed in 2009 is intended to establish a collaborative process between local monitoring parties and DWR to collect groundwater elevations statewide and make them available to the public.

To comply with CASGEMs:

- Local parties may assume responsibility for monitoring and reporting groundwater elevations.
- DWR will work cooperatively with local monitoring entities to achieve monitoring programs that demonstrate seasonal and long-term trends in groundwater elevations.
- A 'Monitoring Entity' is identified for each basin to coordinate monitoring in the basin and the reporting to DWR.
- Where a Monitoring Entity is not established, DWR will perform the monitoring functions. If local parties do not volunteer to perform the groundwater monitoring functions, DWR will assume those functions, and those parties will become ineligible for water grants and loans from the State.

The major deadlines for this effort include:

- On or before January 1, 2011: parties seeking to assume groundwater level elevation monitoring functions must notify DWR.
- On or before January 1, 2012: Monitoring entities shall begin reporting seasonal groundwater elevation measurements.

To comply with CASGEMs Program requirements the District should consider the following actions:

- The San Luis Obispo County FCWCD should be identified with DWR as the groundwater monitoring lead in the Paso Robles Basin.
- Document the recent effort completed to evaluate the existing groundwater level monitoring network to determine the status of the existing wells and identify new wells to be included in network.
- Continue to coordinate data collection efforts among local agencies and data exchange with DWR.
- Submit a copy of the 2009/2010 Groundwater Level Monitoring Report to DWR to comply with their reporting requirements.

4.2 Improving the Existing Voluntary Monitoring Network

The District currently encourages well owners to consider adding their wells to the voluntary monitoring network. Figure 2-2 identifies areas where additional monitoring wells are needed to fill in gaps in the groundwater level monitoring network. The purpose of improving the voluntary monitoring network includes:

- Increasing the number of wells in groundwater level monitoring network
- Collecting available well construction data for existing wells included in monitoring network to improve understanding of aquifer being represented by each well
- Expanding the monitoring network to include areas experiencing changes in groundwater levels or changing land use conditions

Expanding the voluntary groundwater level monitoring network could be done by:

- Developing an outreach and education program to increase the understanding of the importance of the monitoring program
- Developing support for the program among responsible stakeholder groups to encourage participation among their membership
- Identifying specific locations needed for additional monitoring and identifying interested well owners

Interested well owners should contact the County Department of Public Works to inform them of their interest in making their well available to the District monitoring network. At that point the District will evaluate the candidate well for inclusion in the program. The

County Department of Public Works is currently developing a screening process to include additional wells into the monitoring network that includes the steps described below.

Step 1 – Contact District: Contact the District to confirm your interest in making your well available for inclusion in the voluntary monitoring network. Complete the Volunteer Application Form and provide the following information about your well to the District (Attachment A):

- **Well Location**: To determine if the well is located within a DWR designated groundwater basin, and identify if there are already three or more County monitored wells within a mile of the proposed well that tap the same aquifer.
- **Well Construction Information**: To determine the depth of the well and aquifers being tapped.
- **Existing Groundwater Level Data**: Includes past groundwater level data to determine the history of groundwater levels in the well to compare to other nearby wells.
- **Recent Well History**: To document any recent changes in the well, pumps, or changes in groundwater production or quality.

Step 2 - Initial Assessment: Applies screening criteria to determine the suitability for including the well in the monitoring network.

- **Well Location**: To determine if the well is located within a DWR designated groundwater basin, and identify if there are already three or more County monitored wells within a mile of the proposed well that tap the same aquifer.
- **Well Access**: To determine that there is safe, reliable and relatively easy access to the well.
- **Well Condition**: To confirm that well construction information is available, and if any changes have been made to the well (such as deepening the well).
- **Land Use**: To track historic changes in land use and corresponding groundwater levels, and monitor areas of future anticipated land use changes.
- **Water Levels**: An area experiencing historic water levels trends (rising or dropping) should have nearby County monitored wells to identify the extent of the area showing the trends.

Step 3 - Field Evaluation: Conducted to determine the well accessibility (in the field) and the conditions of the well.

- **Well Access**: To determine that the well:
  - Is free of hazardous conditions or obstacles, and there is safe parking and access to the wellhead.
  - Is accessible in all seasons and bad weather conditions.
  - Has an accessible sounding port that allows entry to the well with an electric sounder.

- **Well Condition**: To determine that the well:
  - Is free of down-hole obstructions that could interfere with water level measurements.
  - Does not have any down-hole problems such as oily conditions.
  - Does not produce any sand which may be an indication of a problem with the well construction.

Suitable wells that pass the 2-step screening process may be added to the Paso Robles Basin groundwater level monitoring network.

4.3 Improving Information on Existing Monitoring Wells

Well construction data may not be available for all wells currently included in the monitoring network. Downhole surveys of some of the existing wells currently being monitored could be conducted to obtain construction details and determine which aquifers are being monitored. These downhole surveys would improve the understanding of the groundwater levels and groundwater movement in the area of the well.

For wells without construction records, video logs could be performed during pump maintenance. Recent technology developments allow down-hole investigation of wells without having to remove their pumps and can provide a video survey to determine their screen intervals; estimate the amount of flow contributed by aquifer (allowing the aquifer characteristics to be estimated) and collect water quality samples by aquifer. These video surveys do have limitations due to the pump column being in the well during the survey. The well owner could notify the County and the well logging service to coordinate these efforts with their pump maintenance.

4.4 Adding Dedicated Monitoring Wells

The groundwater level monitoring network could be expanded by including dedicated monitoring wells to provide long-term continuity of the monitoring program, and fill existing gaps in the monitoring network. Dedicated monitoring wells are typically placed away from production wells so they will not be subject to the effect of pumping wells on their observations. Additionally, dedicated monitoring wells are not subject to removal from the monitoring network which may result if production wells change ownership. Dedicated monitoring wells should be outfitted with transducers to record water level data at selected time intervals. This allows a more detailed glimpse at the changes in groundwater levels over a short duration (hours, days, or weeks) compared to semi-annual monitoring. This can be especially important in the summer months when groundwater pumping is greatest but may not be captured in the spring and fall monitoring.

The dedicated monitoring well network could be expanded to include monitoring wells:

- In critical areas of concern where groundwater levels have declined or are experiencing groundwater level declines.

- In areas where there are data gaps because there are no wells in the existing monitoring well network.
- At the edges of the developed land use in the Basin. These areas may not be experience seasonal or long-term trends associated with localized pumping.

This could be done by:

- Developing a long-term strategy to develop and finance a dedicated monitoring network
- Prioritizing the areas of greatest concern to install dedicated monitoring wells
- Identifying specific locations (parcels) to site dedicated monitoring wells
- Pursue grant funding opportunities to implement the dedicated monitoring network

Figure 2-2 identifies areas that may be suitable for adding dedicated monitoring wells. These locations may be modified by the CASGEMs guidelines when they are released (expected in Fall 2010).

The dedicated monitoring network should be designed in such a fashion that it could eventually replace the use of production wells for the purpose of monitoring groundwater levels. When established, the dedicated monitoring well network may include between 20 to 40 wells. Initially, ten to fifteen wells could be added in those locations described previously. The actual location each well should be evaluated in the context of the large dedicated monitoring network so as to optimize the value of each well. Developing an effective and efficient dedicated monitoring network (with regard to the number of wells and their locations) could reduce the installation costs and future monitoring costs. The cost of the installation of dedicated monitoring wells ranges in the Paso Robles Basin is currently estimated at $30,000 to $40,000,

4.5 Relationship of Resource Capacity Study and Groundwater Level Monitoring Program

The Resource Capacity Study (RCS) addresses the state of the Paso Robles Groundwater Basin based on whether the Basin is being used at or beyond its dependable supply currently or will be within a certain period of time. The RCS uses available studies that calculated the perennial yield and water use by major water use sectors (agriculture, rural land uses, small commercial uses, municipal systems, and small community systems) in order to make this determination. The results of these studies show that groundwater use has increased during the 1980 to 2009 period to the point where the Basin outflows (including groundwater pumping) will soon be greater that Basin inflows (recharge). The RCS includes recommendations for land-use and monitoring actions based on the results of the studies.

The RCS recognizes that there are over-arching issues that complicate any action the County might wish to take, two of which are related to the Groundwater Level Monitoring Plan:

1. The major portion of Basin outflows are not measured, but are estimated. While municipal pumping is measured, agricultural, rural, and small community/commercial pumping is estimated. This adds to the uncertainty regarding actual groundwater use.

2. Identification of changing groundwater levels is based on limited data.

Because the County is the lead agency in coordinating the collection of groundwater level data, the Monitoring Plan should be regularly reviewed to ensure consistency with any monitoring actions ultimately implemented by the County.

4.6 Summary of Improvements

The following list summarizes the suggested improvements to the groundwater level monitoring network described in this section:

- The San Luis Obispo County FCWCD should be identified with DWR as the Monitoring Entity in the Paso Robles Basin.
- Document the recent effort completed to evaluate the existing groundwater level monitoring network to determine the status of the existing wells and identify new wells to be included in network
- Continue to coordinate data collection efforts among local agencies and data exchange with DWR
- Submit a copy of the 2009/2010 Groundwater Level Monitoring Report to DWR to comply with their reporting requirements.
- Develop an outreach and education program to increase the understanding of the importance of the monitoring program and foster support for the program among individuals and stakeholder groups to encourage participation among their membership
- Inform private wells owners about the 2-step process to add their well to the voluntary monitoring well network.
- Identify specific locations needed for additional wells in the voluntary monitoring network and interested well owners in those areas
- Develop a long-term strategy and finance plan to evaluate the development of a dedicated monitoring network
- Prioritize the areas of greatest concern to install dedicated monitoring wells and identify specific locations (parcels) to site dedicated monitoring wells
- Secure the right to access all new key wells together with retaining voluntary access to existing wells having useful histories to ensure that the County's investment in these records is protected.
- Prioritize the areas of greatest concern to install dedicated monitoring wells and identify specific locations (parcels) to site dedicated monitoring wells

- Continue to conduct semi-annual groundwater measurements to chart the scope of groundwater level changes

Attachment A

PASO ROBLES GROUNDWATER BASIN
GROUNDWATER MANAGEMENT PLAN

Groundwater Level Monitoring Network
Well Interest Form

Well Location: _____

Subarea:_____

Address:_____

Well Construction Information (total depth/ depth of well screens/(gpm):

_____

_____

Existing Groundwater Level Data:

- What are the current trends in groundwater levels in your well?

_____

_____

Recent Well History:

- Have you had to take any actions related to maintain production in your well (deepen wells/ replace pump/ lower pumps)?

_____

_____

General Comments:

_____

_____

_____

_____

Volunteer Application Form

SAN LUIS OBISPO COUNTY
DEPARTMENT OF PUBLIC WORKS

County Government Center, Room 207 • San Luis Obispo CA 93408 • (805) 781-5252

(Please print or write legibly)

Name: _____ Date: _____

Address: _____ PO Box: _____

City: _____ State: _____ Zip: _____ County: _____

Home Phone: ( ) _____ Daytime Phone: ( ) _____

Email Address: _____ Daily Internet Access: Yes / No

Give a brief description of your location (Latitude/Longitude and assessor's parcel number if available):

_____

_____

Nearest Cross streets/roads:

_____

_____

Please use the box on the right to draw a map of your site and /or attach a picture.

Diagram of Site:

How did you find out about volunteering? _____

Please return this form to:

Kim Hubbs
County Government Center, Room 207
San Luis Obispo, CA 93408

Fax Number: (805) 788-2182
Phone Number: (805) 781-5272

For Staff Use Only

Station Name: _____
Station Number: _____
Latitude: _____ Longitude: _____
Date of Field Review: _____
Date Station Num Issued: _____
Date Received/Shipped Gauge: _____

Thank you for volunteering!

5 References

California Department of Water Resources, California's Groundwater, Bulletin 118 – Update 2003, 2003.

Cleath & Associates, Paso Robles Groundwater Monitoring Program Evaluation, 2003.

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Todd Engineers, Update for the Paso Robles Groundwater Basin, 2007.

Valentine, D.W., et al. Use of InSAR to Identify Land-surface Displacements Caused by Aquifer-System Compaction in the Paso Robles Area, San Luis Obispo County, California. USGS Open File Report 00-447, 1997.

Yates, Gus, Peer Review of Paso Robles Groundwater Studies, 2010.

Appendix F Annual Monitoring Report

Annual Monitoring Report for Calendar Year 2009

City of Paso Robles

Submitted to:
Paso Robles Groundwater Basin –
Groundwater Advisory Committee

Date: February 9, 2011

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1 Introduction

The purpose of this report is to summarize groundwater conditions in the Paso Robles Groundwater Basin for 2009. This report supports the implementation of the Paso Robles Groundwater Management Plan (Plan) completed in February 2011 by:

- Documenting annual changes in groundwater levels based on information collected from the existing monitoring network.
- Comparing changes in groundwater levels to the Basin Management Objectives (BMOs) identified in the Plan.
- Identifying Groundwater Management Activities (GMAs) undertaken during the development of the Groundwater Management Plan and identifying activities anticipated to be undertaken in 2011 in an attempt to meet the BMOs.

1.1 Paso Robles Groundwater Basin

The Paso Robles Groundwater Basin (Basin) is located in northern San Luis Obispo County (County) and southern Monterey County and was described in the 1958 California Department of Water Resources (DWR) Bulletin 118, San Luis Obispo County Investigation. As part of the efforts to map the groundwater basins in the State of California (State) presented in Bulletin 118, DWR identified the Paso Robles Area Groundwater Subbasin of the Salinas Valley Groundwater Basin and designated it as Basin Number 3-4.06. The Basin boundary was later updated in the Paso Robles Groundwater Basin Study (2002) and is shown on Figure 1-1.

The Basin was first formally defined by the California Department of Water Resources (DWR, 1958). In 1979, the DWR published a detailed investigation of the San Luis Obispo County portion of the Basin (DWR, 1979).

The Basin encompasses an area of approximately 505,000 acres (790 square miles). The Basin ranges from the Garden Farms area south of Atascadero to San Ardo in Monterey County, and from the Highway 101 corridor east to Shandon (Figure 1-1). Most of the Basin is hydraulically connected by thick sedimentary sections. The Basin is divided into smaller subareas based on water quality, source of recharge, groundwater movement, and the contours of the base of permeable sediments.

The Atascadero Subbasin is defined as that portion of the Basin west of the Rinconada fault. Between Atascadero and Creston, the Rinconada fault juxtaposes less permeable Monterey Formation rocks with the Paso Robles Formation basin sediments. South of the City of Paso Robles, the Paso Robles Formation is found on both sides of the Rinconada fault; however, the fault zone is believed to form a leaky barrier that restricts flow from the Atascadero Subbasin to the main part of the Basin. As a result of this, the Atascadero Subbasin is

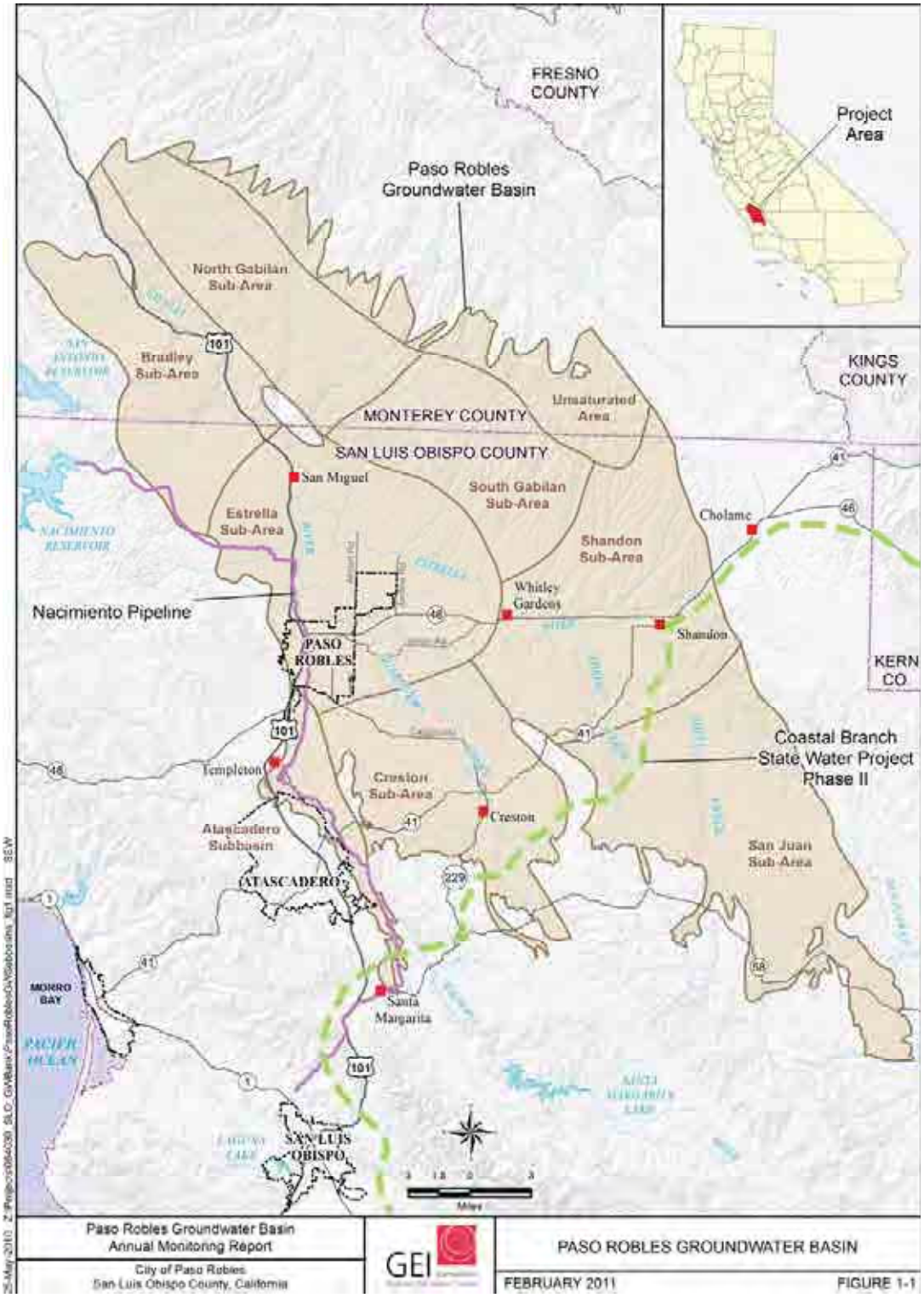
considered a hydrologically distinct subbasin within the Basin. The Rinconada Fault does not act as a hydraulic barrier to groundwater flow in the Salinas River Alluvium. As such, groundwater flow in the Alluvium is continuous along the stretch of the Salinas River that traverses the entire Basin. The Atascadero Subbasin encompasses the Salinas River corridor area south of Paso Robles and includes the communities of Garden Farms, Atascadero, and Templeton.

The western boundary of the Basin roughly follows Highway 101 from Santa Margarita northward to Hames Valley. The eastern boundary follows a rough line from Highway 58 in the San Juan Creek area northward to Shandon and Cholame. The Basin is downstream of and hydraulically connected by alluvial deposits to the Pozo Groundwater Basin south of the Basin, and to the Cholame Groundwater Basin north of the Basin. The Basin outlet is northwest and downstream of Bradley, where it is hydraulically connected with the Salinas Valley Groundwater Basin.

The Basin was subdivided into subareas in the Phase I Report (Fugro, 2002) as a practical approach to organize the 790 square mile Basin into smaller informal areas (see Figure 1-1) listed below:

1. Atascadero Subbasin
2. Creston Subarea
3. San Juan Subarea
4. Estrella Subarea
5. Shandon Subarea
6. North Gabilan Subarea
7. South Gabilan Subarea
8. Bradley Subarea

Figure 1-1. Paso Robles Groundwater Basin



1.2 Groundwater Level Monitoring Network

In the Basin, the County has been monitoring groundwater levels for more than 40 years. In 2003, an evaluation of the monitoring network was completed to evaluate the efficiency and effectiveness of the County's Monitoring Program for wells located in the Basin. Based on the final report, approximately 159 wells in the monitoring program (see Figure 1-2). Most wells are monitored by County Public Works employees and the remaining wells are monitored by local municipal water company employees (who forward the data to the County's Public Works department for inclusion in the monitoring program database). Additionally, three wells are located in Monterey County and are monitored by the Monterey County Water Resources Agency.

The County's Monitoring Program provides the best available groundwater elevation information to guide current groundwater management activities at current levels of implementation.

Figure 1-2. Monitoring Well Locations

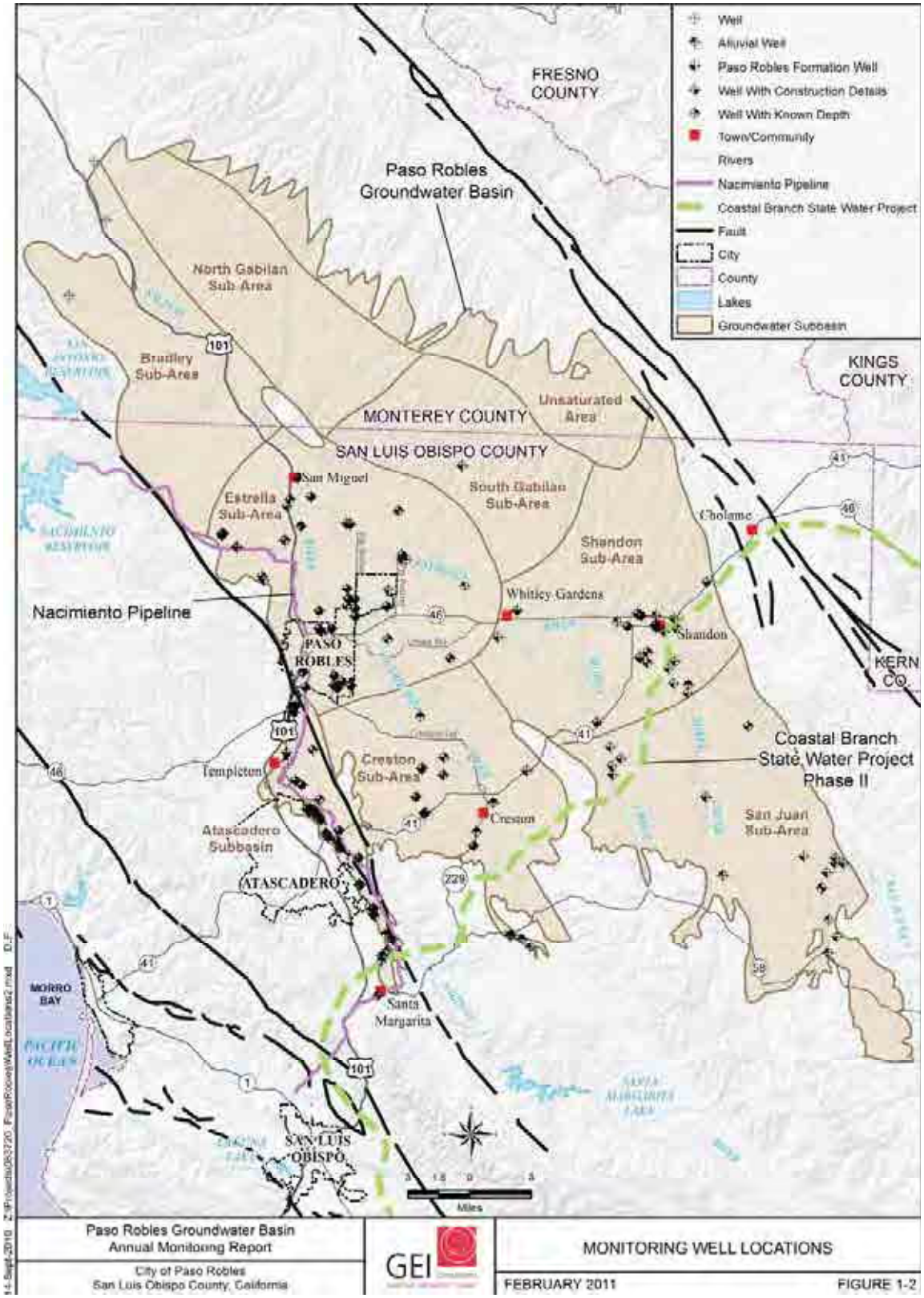


Table 1-1. Wells in the San Luis Obispo County Monitoring Network

Groundwater Subarea	Wells Currently in Program
Atascadero Subbasin	51
Bradley	0
Creston	17
Estrella	50
Gabilan (North and South)	1
San Juan	16
Shandon	24
TOTAL	**159**

2 Conditions for Calendar Year 2009

This section describes the conditions in the Paso Robles Groundwater Basin for calendar year 2009, including:

- Land and water use conditions
- Surface water imports
- Hydrologic conditions
- Groundwater elevations
- Groundwater quality data

2.1 Land and Water Use Conditions

The water demands and supplies for the Paso Robles Groundwater Basin are summarized from several of the documents as described in the Plan. Historically, all water demands in the Basin have been met with groundwater. This changed in early 2011 when Nacimiento Project Water began delivering water to some water users in the Basin.

Water demands in the Basin have generally been organized into five different "user sectors" including:

- **Agricultural -** Agricultural water demands are estimated using the crop acreage and water demands of different types of crops to determine the overall agricultural water demand. This method is used because records of agricultural pumping are not kept and reported.
- **Municipal -** Municipal pumping in the Basin includes four public water purveyors: 1) City of Paso Robles; 2) Atascadero Mutual Water Company; 3) Templeton Community Services District (CSD); and 4) San Miguel Community Services District. Pumping records were used to accurately calculate total municipal pumping.
- **Rural Residential -** Rural pumping includes domestic water use by development in rural areas. The estimate was derived by using parcel data and applying a water use factor, since records are not kept and reported.
- **Small Community Systems -** Small community systems include mutual water companies, county service areas, and mobile home parks. For systems that report groundwater pumping, well records were used to accurately determine their pumping. Using these reports, estimates were derived for the systems that do not report their water use.
- **Small Commercial Systems -** Small commercial pumping includes such users as wineries, golf courses, and schools. Water use estimates are based on factors from the Pacific Institute and information from consultation with winery operators.

The most recent Basin-wide water demand data is available for 2006 conditions, which are believed to represent approximate conditions for 2009. This information will be updated in the future as additional information is collected.

Table 2-1 shows the distribution of the demands by demand type and subarea for 2006. In 2006, agricultural demands were about 67 percent of the total demand in the Basin, with about one-third of the total agricultural demand occurring in the Estrella Subarea. Municipal demands were about 18 percent of the total demand and are concentrated in the Atascadero Subbasin and the Estrella Subarea. The small community demands are included as part of rural domestic demands. Rural domestic demands were about 13 percent of the total demand. Small commercial demands total about three percent of the total demand, and are concentrated in the Estrella Subarea.

Table 2-1. Distribution of 2006 Water Demands to Subareas

Subarea	Demand Type						
	Agriculture	Municipal	Small Community Systems	Small Commercial Systems	Rural Domestic	Total	Percentage
Atascadero Subbasin	1,348	11,735	0	430	2,032	15,545	17%
Bradley	6,933	0	0	184	109	7,226	8%
Creston	9,936	0	0	37	2,338	12,311	14%
Estrella	23,111	3,930	0	1,603	5,433	34,077	38%
North Gabilan	1,758	0	0	0	50	1,808	2%
San Juan	5,347	0	0	0	105	5,452	6%
Shandon	9,896	0	0	69	1,205	11,170	12%
South Gabilan	1,671	0	0	0	213	1,884	2%
Total	**60,000**	**15,665**	**0**	**2,323**	**11,485**	**89,473**	**100%**
Percent of Total	**67%**	**18%**	**0%**	**3%**	**13%**	**100%**	

2.2 Surface Water Imports

Several agencies and communities are participating in the Nacimiento Water Project to bring surface water into the Paso Robles Groundwater Basin. Table 2-2 lists the contract amounts and will track annual deliveries by year. Deliveries from the Nacimiento Project are expected to begin in early 2011.

Table 2-2 Imported Supplies from the Nacimiento Water Project

Entity	Contract Amount (Acre-Feet)	2010	2011	Total
City of Paso Robles	4,000	0		
Atascadero MWC	2,000	0		
Templeton CSD	250	0		
Total	6,250	0		

2.3 Hydrologic Conditions

The Paso Robles Groundwater Basin has a semi-arid Mediterranean climate, which is characterized by hot sunny summers and cool winters. Most of the precipitation occurs in the winter between November and April.

Rainfall is the primary source of recharge to the groundwater basin, and it is important to understand rainfall's relationship to groundwater management activities in the basin. The average rainfall over the basin ranges from about 18 inches in the west (at the Atascadero MWC Gage #34) to 11 inches in the east (at the Shandon #73) as shown on Table 2-3. Figure 2-1 shows the location of selected precipitation stations in the basin. The historical annual rainfall recorded is represented along the Salinas River at Paso Robles Gage (Gage #10) for the 1960 to 2009 period (50 years), shown on Figure 2-2. During this period, rainfall was highly variable, ranging from about 5 inches to over 30 inches per year, and averaging 14.88 inches per year.

Table 2-3. Precipitation Stations in the Paso Robles Groundwater Basin

Precipitation Station	Period of Record	Average Annual Precipitation (inches)			
		Period of Record	1960 to 2009	1981 to 2009	1997 to 2009
Paso Robles Gage #10	1901 to 2009	15.04	14.88	14.49	13.73
Atascadero Mutual WC #34	1931 to 2009	17.65	17.85	17.58	17.49
Erickson Ranch 52.1	1928 to 2009	11.89	12.81	12.85	13.15
Shandon # 73	1937 to 2009	10.69	10.76	11.10	11.06
Sinclair #125	1949 to 2009	11.69	12.02	12.21	11.67

Figure 2-1. Precipitation and Surface Water Gaging Stations in the Paso Robles Area

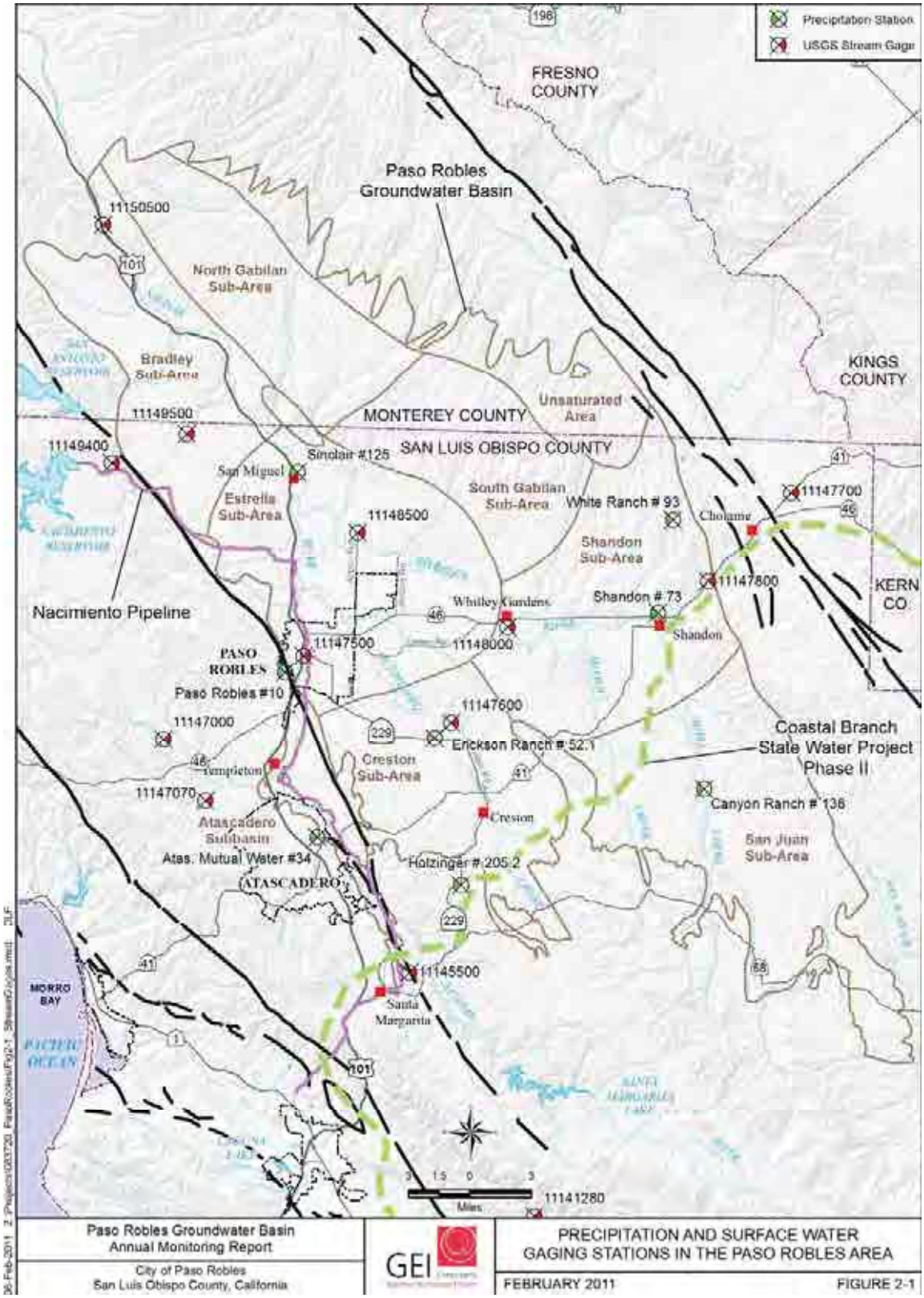
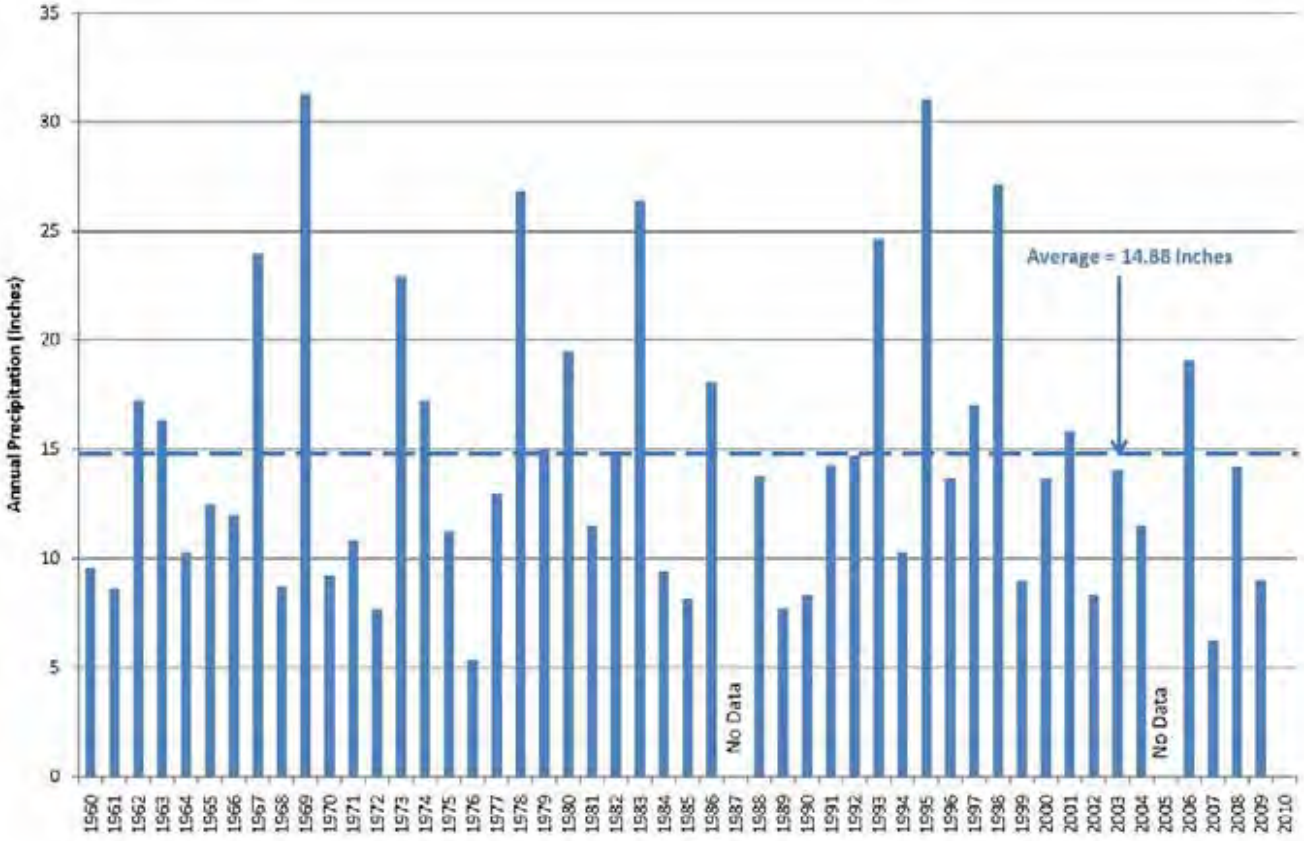


Figure 2-2. Annual Precipitation at the Paso Robles Gage for 1960-2009



2.4 Groundwater Levels

2.4.1 Current Groundwater Levels

Spring 2009 shows that groundwater levels in the Basin range from approximately 1,500 feet above mean sea level (msl) in upland areas to less than 600 feet msl in the northwestern Bradley area as shown on Figure 2-3. Groundwater moves generally northwesterly from the San Juan area into Shandon and then into the Estrella area. Groundwater flow from Creston is also northerly into the Estrella area. In the northern portion of the Basin, groundwater moves southwesterly toward Estrella and the Salinas River in the area near San Miguel.

2.4.2 Long-Term Change in Groundwater Levels

A groundwater elevation change map has been prepared that represents the changes in groundwater levels for the 1997 to 2009 period and is shown on Figure 2-4. This map shows that the greatest change in groundwater elevations has occurred in the Estrella Subarea, and to a lesser extent in the Creston and Shandon Subareas. Groundwater levels in the western portion of the Paso Robles Basin have declined in excess of 70 feet since 1997 during a period when precipitation was just slightly less than the long-term average annual precipitation.

2.4.3 Groundwater Quality

In general, the quality of groundwater in the Basin is relatively good, with few areas of poor quality or trends of ongoing water quality deterioration. Historical water quality trends were evaluated to identify areas of deteriorating water quality. Some areas are experiencing rising concentrations of total dissolved solids (TDS), chloride, and nitrate. The water quality data is collected by entities that deliver potable water. Table 2-4 provides a range of values for selected water quality constituents for agencies within the Paso Robles Basin.

The first dataset was provided by the San Luis Obispo County Department of Public Works Water Quality Database. Values from this dataset are measured in milligrams per liter (mg/L) or micrograms per liter (ug/L). These ranges were calculated from the provided dataset and cover a variety of wells under the jurisdiction of each listed entity.

The second dataset was gleaned from annual water quality reports provided by water agencies or cities. Values from this dataset are measured in parts per million (ppm) or parts per billion (ppb). Ranges were provided in each report and are unique to that agency's analysis set.

Table 2-4. Selected Groundwater Quality Data

Agency/Project	Analysis Full Name	Range	Units
SAN LUIS OBISPO CSA #16 - SHANDON	Chloride	61.7 - 114	mg/L
	Manganese	< 5	ug/L
	Nitrate and Nitrite Combined as Nitrogen	2420 - 4130	ug/L
	Nitrate as Nitrogen	2420 - 4140	ug/L
	Nitrate as NO3	10.7 - 18.3	mg/L
	Total Dissolved Solids	390 - 550	mg/L
SAN LUIS OBISPO CSA 23 - SANTA MARGARITA	Arsenic	< 1.0 - 6.2	ug/L
	Manganese	<5 - 12	ug/L
	Nitrate as Nitrogen	< 100 - 321	ug/L
	Nitrate as NO3	< 0.443 - 1.4	mg/L
SAN MIGUEL COMMUNITY SERVICES DISTRICT	Chloride	78.8 - 114	mg/L
	Manganese	< 5 -	ug/L
	Nitrate and Nitrite Combined as Nitrogen	3500 - 3600	ug/L
	Nitrate as Nitrogen	2340 - 11200	ug/L
	Nitrate as NO3	10.4 - 49.6	mg/L
	Total Dissolved Solids	580 - 770	mg/L
SANTA MARGARITA RECREATION AREA	Nitrate as Nitrogen	- <100	ug/L
	Nitrate as NO3	- < 0.443	mg/L
CITY OF PASO ROBLES	Arsenic	ND - 6.3	ppb
	Chloride	35 - 150	ppm
	Manganese	ND - 27	ppb
	Nitrate and Nitrite Combined as Nitrogen	ND - 3500	ppb
	Nitrate as Nitrogen	---	---
	Nitrate as NO3	ND - 28.5	ppb
	Total Dissolved Solids	370 - 740	ppm
ATASCADERO MUTUAL WATER COMPANY	Arsenic	---	---
	Chloride	11 - 220	ppm
	Manganese	ND - 0.046	ppb
	Nitrate and Nitrite Combined as Nitrogen	---	---
	Nitrate as Nitrogen	---	---
	Nitrate as NO3	ND - 16	ppb
	Total Dissolved Solids	350 - 990	ppm
TEMPLETON COMMUNITY SERVICES DISTRICT	Arsenic	0 - 12	ppb
	Chloride	57 - 165	ppm
	Manganese	0 - 7.8	ppb
	Nitrate and Nitrite Combined as Nitrogen	---	---
	Nitrate as Nitrogen	0 - .95	ppm
	Nitrate as NO3	0 - 43	ppb
	Total Dissolved Solids	560 - 1000	ppm

2.4.4 Land Subsidence

There has been no significant long-term land subsidence in the Basin so currently there are no plans to develop a formal program to monitor and measure the rate of inelastic land surface subsidence within the Basin. The need for land subsidence monitoring will continue to be considered on an annual basis.

Figure 2-3. Groundwater Elevations Spring 2009

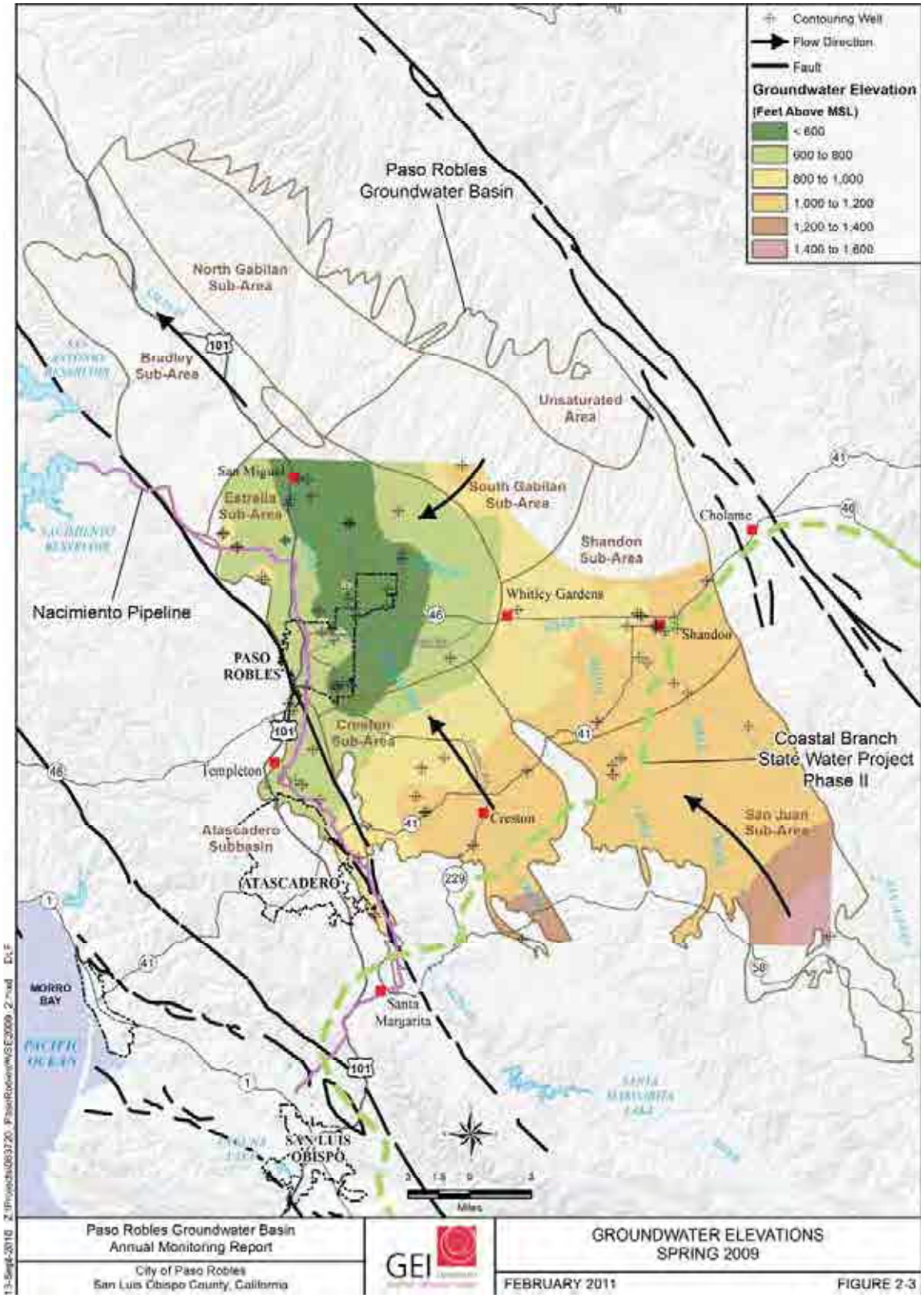
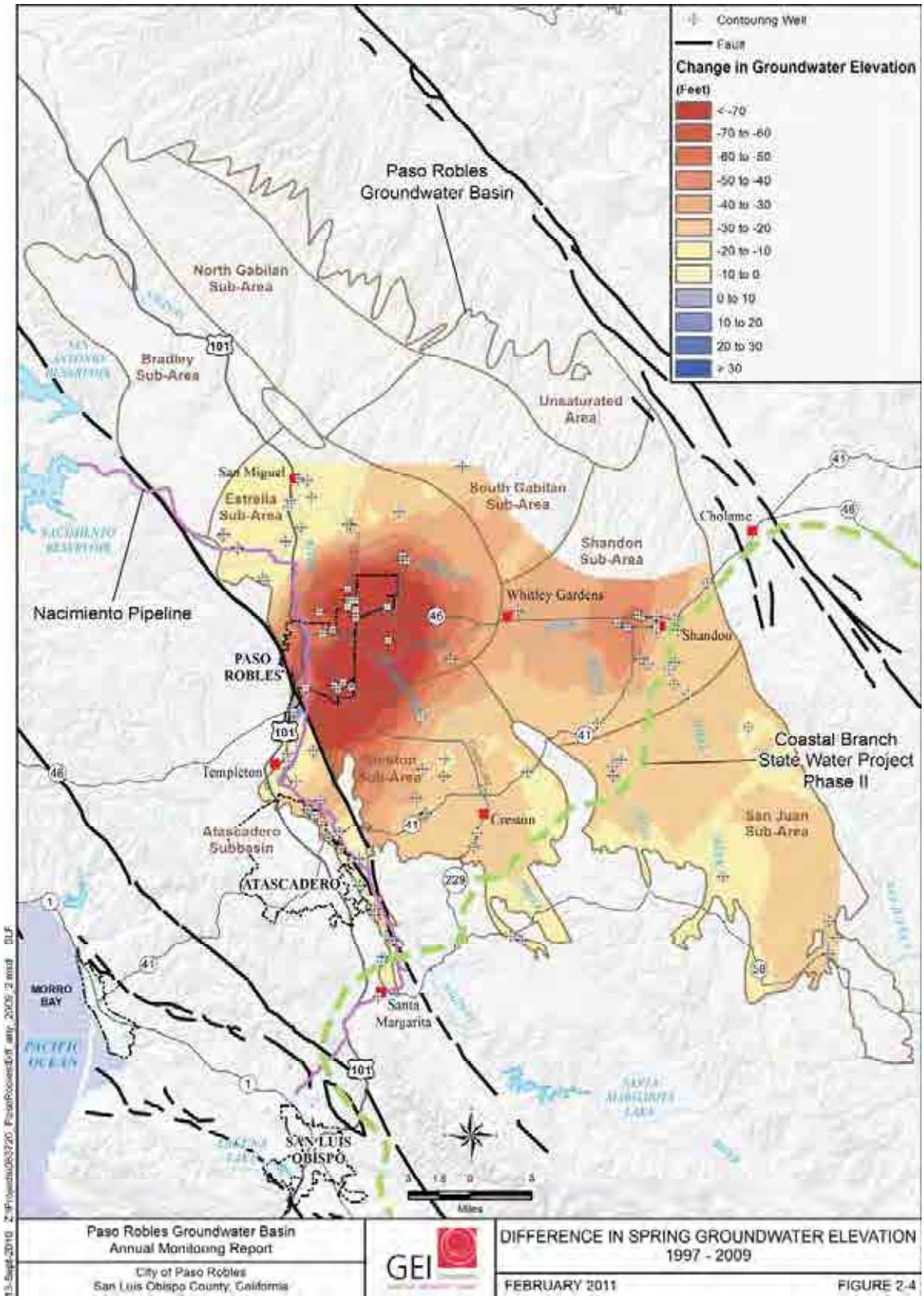


Figure 2-4. Difference in Spring Groundwater Elevations 1997 to 2009



3 Basin Management Objectives

During the development of the Groundwater Management Plan, the groundwater level BMOs established by the stakeholders for each subarea are listed in Table 3-1. The BMOs are used to establish a long-term management goal for groundwater levels. Each year, the measured groundwater levels will be compared to the groundwater level BMO to determine the condition of the Basin. This information will be reported by the Steering Committee to the Groundwater Advisory Committee and other interested parties and stakeholders to improve the understanding of the current conditions of the groundwater basin, and support future groundwater management decisions.

In general, the initial groundwater level BMO was selected by the subarea stakeholders to maintain or stabilize groundwater levels at or near current conditions. Several subareas identified this as the initial BMO with the expectation that stabilizing groundwater levels needed to be achieved before improving groundwater levels could be considered.

Table 3-1. Basin Management Objective by Subarea

Subarea/Subbasin	Basin Management Objective (BMO)
Atascadero	Stabilize groundwater levels at 2009 levels
Bradley	Maintain groundwater levels
Creston	Stop decline and stabilize levels at 2009 levels
Estrella	Stabilize groundwater levels
North Gabilan	Maintain groundwater levels
San Juan	Maintain groundwater levels
Shandon	Stabilize groundwater levels
South Gabilan	Maintain groundwater levels

A summary of groundwater level conditions is presented below for each subarea based on the BMO hydrographs prepared during the development of the Paso Robles Basin Groundwater Management Plan.

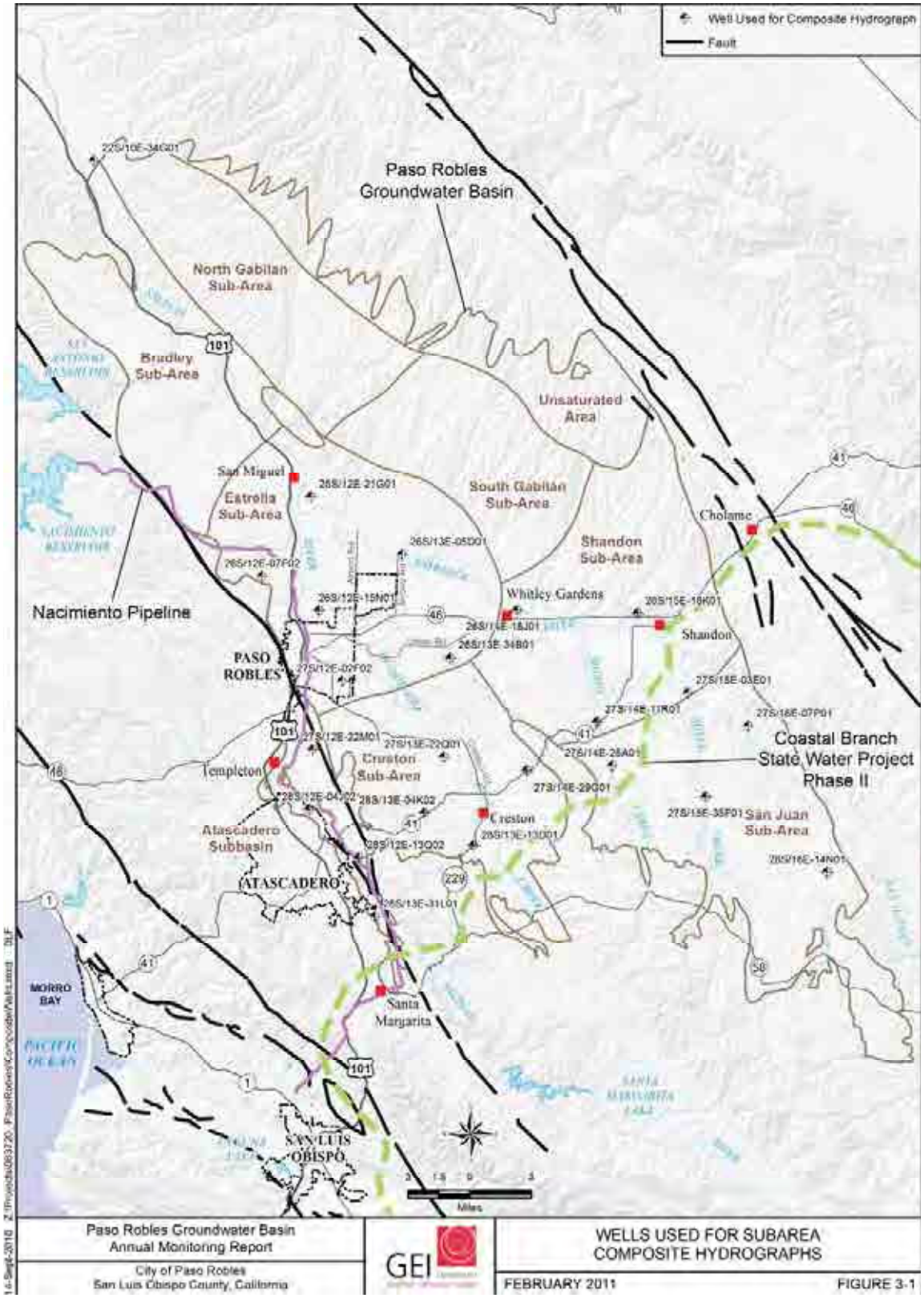
As part of the development of groundwater level BMOs, key wells were identified within each subarea to establish the representative groundwater levels that will be used to monitor the change in groundwater levels. Since the Paso Robles Basin groundwater monitoring network is voluntary, there is a limited amount of information that is available to identify key wells. The key wells were selected based on number of monitoring observations during the 1981 to 2009 period of record and the geographic location within the subarea. The wells meeting these two criteria were identified as key wells and used to develop the subarea hydrographs. The locations of these key wells used to create the subarea-specific BMO hydrographs are shown on Figure 3-1.

In addition to the BMO hydrograph that shows annual changes in groundwater levels for the 1981 to 2009 period, a summary table presenting the recent changes (since 2008) in groundwater levels is provided for each subarea. This table provides an annual comparison of the following:

- The annual change in the groundwater level associated with BMO hydrograph
- The cumulative change in groundwater levels since 1981
- A comparison of the current groundwater level to the established BMO groundwater level

This information can be used to determine the groundwater levels trends, determine the effectiveness of current groundwater management activities, and provide direction for future activities.

Figure 3-1. Wells Used for Subarea Hydrographs



3.1 Atascadero Subbasin

The location of the four wells identified to be representative of changes in groundwater level conditions in the Atascadero Subbasin is shown on Figure 3-1. The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Atascadero Subbasin is included in Figure 3-2.

This figure shows that in a single year, the average groundwater level can increase or decrease by up to 15 feet. The overall trend of the average groundwater levels has remained relatively constant since the early 1980s with groundwater levels rising and falling primarily in response to changing hydrologic conditions and increasing demands.

Figure 3-2. Atascadero Subbasin Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	Atascadero
Basin Name	Atascadero

Sub-Area Well Records	
Period of Record	1966-2009
Num. BMO Wells	4

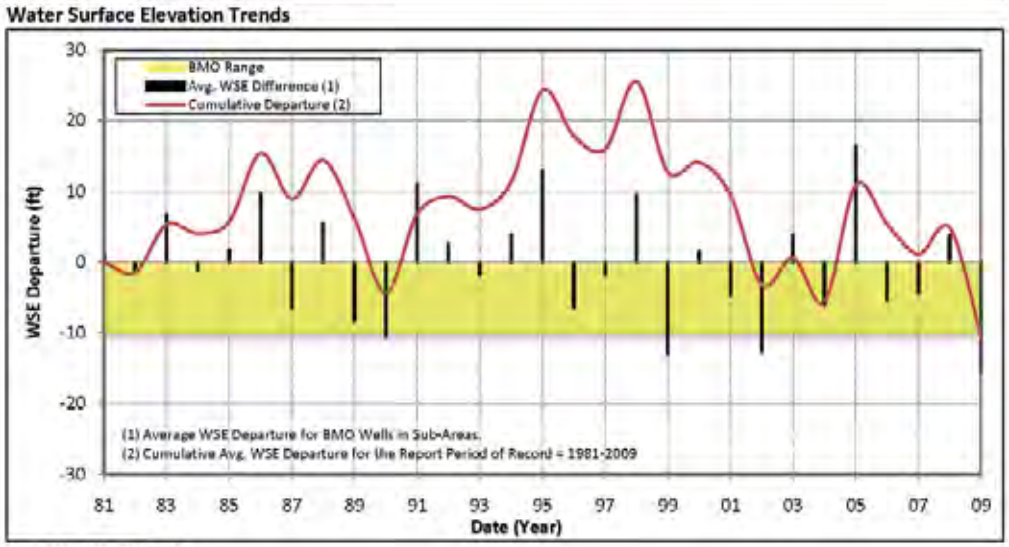
Report Information	
Report Start Year	1981
Period of Record	1981-2009

Raingage Information	
Raingage Name	Atas. Mutual Water # 34
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1966-2009
Average Precip.	17.64 in

Trend Analysis Results	
BMO Departure[1]	(10.00 ft)
2009 Departure	(10.75 ft)

NOTES: 1) BMO Cumulative Departure Since 1981



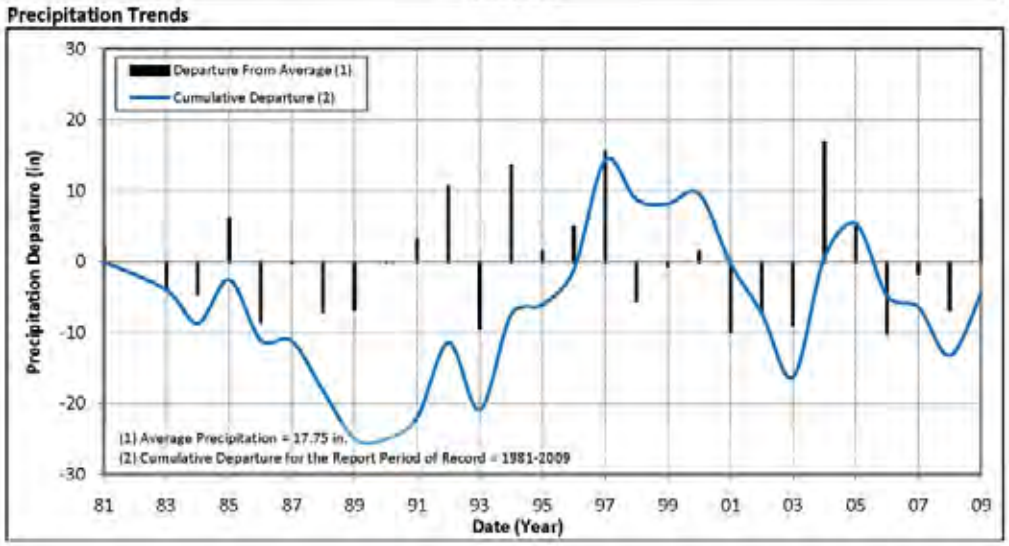


Table 3-2 presents the changes in BMO groundwater levels in the Atascadero Subbasin since 2008. In 2008, the composite BMO groundwater levels increased by 3.7 feet resulting in a cumulative groundwater level change since 1981 of +4.9 feet (14.8 feet above the BMO level). In 2009, the composite BMO groundwater levels decreased by 15.6 feet resulting in a cumulative groundwater level change of -10.8 feet (0.8 feet below the BMO level) since 1981.

At this time, groundwater levels in the Atascadero Subbasin are just below the established BMO level. This is the first time the observed BMO groundwater level has dropped below the established BMO level.

Table 3-2. Changes BMO Groundwater Levels in the Atascadero Subbasin

Period	Annual Change (feet)	Cumulative Change Since 1981 (feet)	Comparison of Cumulative Change to BMO Level (feet)
BMO Groundwater Level			**-10**
2008 Observed Level	3.7	+4.8	+14.8
2009 Observed Level	-15.6	-10.8	-0.8

3.2 Bradley Subarea

The changes in groundwater levels in the Bradley Subarea are currently recorded at one well that is included in the groundwater monitoring network of Monterey County Water Resources Agency (MCWRA). Construction details for this well are unknown and it may not be representative of groundwater levels throughout the Bradley Subarea. The lack of data prevents the development of groundwater level hydrographs or composite hydrographs as developed for other subareas. At this time, we are not aware of any reports or anecdotal information that suggests groundwater levels in the Bradley Subarea are declining to the point of causing problems for local groundwater users.

3.3 Creston Subarea

The location of the four wells identified to be representative of changes in groundwater level conditions in the Creston Subarea is shown of Figure 3-1. The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Creston Subarea is included in Figure 3-3. This figure shows the average groundwater levels in the subarea appear to have peaked at about 1999. Since this time, groundwater levels have generally declined. This may be due to the increase in water demands between 1997 and 2006.

Figure 3-3. Creston Subarea Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	Creston
Basin Name	Paso Robles

Sub-Area Well Records	
Period of Record	1960-2009
Num. BMO Wells	4

Report Information	
Report Start Year	1981
Period of Record	1981-2009

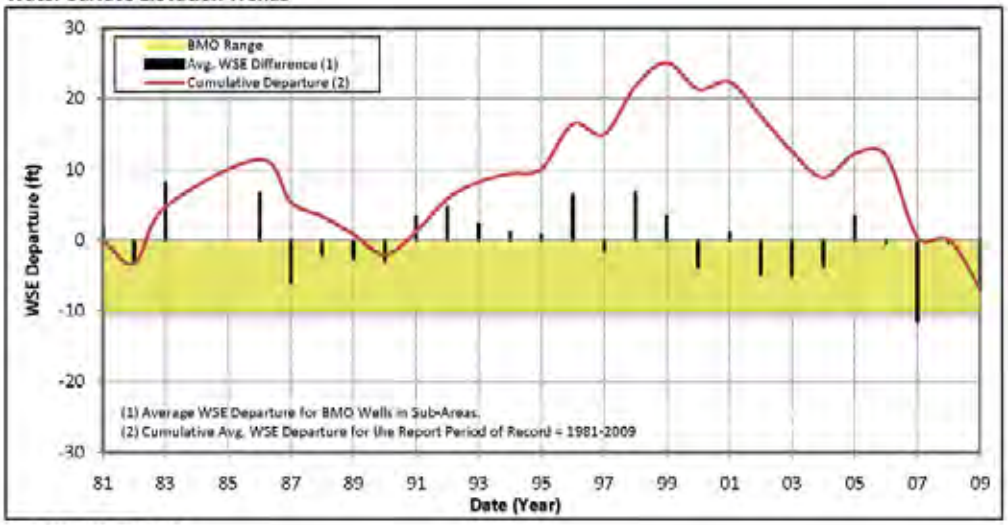
Raingage Information	
Raingage Name	Atas. Mutual Water # 34
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1960-2009
Average Precip.	17.64 in

Trend Analysis Results	
BMO Departure[1]	(10.00 ft)
2009 Departure	(6.91 ft)

NOTES: 1) BMO Cumulative Departure Since 1981

Water Surface Elevation Trends



Precipitation Trends

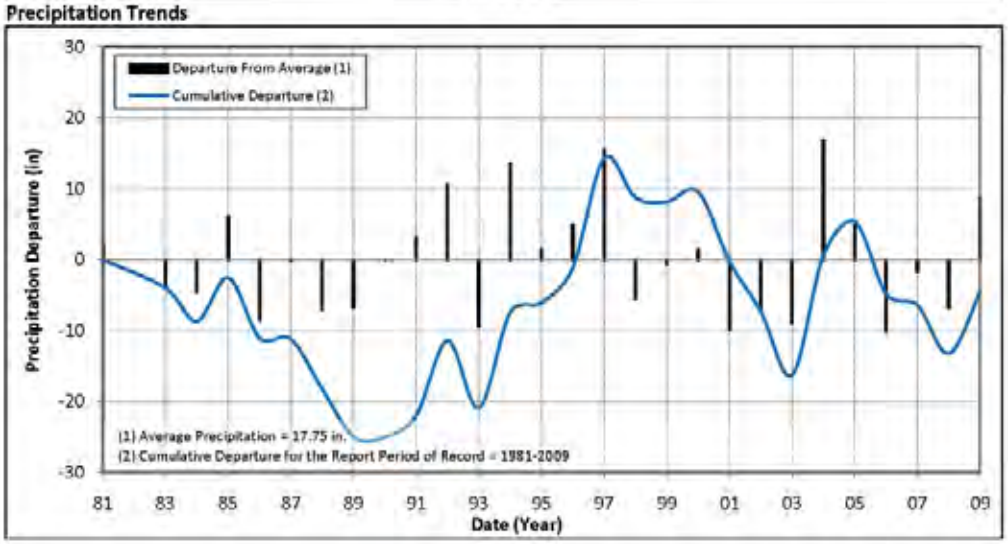


Table 3-3 presents the changes in BMO groundwater levels in the Creston Subbasin since 2008. In 2008, the composite BMO groundwater level decreased by 0.3 feet resulting in a cumulative groundwater level change of +0.1 feet since 1981 (10.1 feet above the BMO level). In 2009, the composite BMO groundwater level decreased by 7.0 feet resulting in a cumulative groundwater level change of -6.9 feet since 1981 (3.1 feet above the BMO level).

At this time, groundwater levels in the Creston Subarea are just within the established BMO level. It should be noted that the BMO wells selected from the Creston Subarea are not entirely representative of the entire subarea because no wells were available in the northwestern portion of the subarea. Based on the low and declining groundwater levels in the adjacent Estrella Subarea, groundwater levels in the northwestern portion of the Creston Subarea are anticipated to be lower than other parts of the subarea.

Table 3-3. Changes BMO Groundwater Levels in the Creston Subarea

Period	Annual Change (feet)	Cumulative Change Since 1981 (feet)	Comparison of Cumulative Change to BMO Level (feet)
BMO Groundwater Level			**-10**
2008 Observed Level	-0.3	+0.1	+10.1
2009 Observed Level	-7.0	-6.9	+3.1

3.4 Estrella Subarea

The location of the six wells identified to be representative of changes in groundwater level conditions in the Estrella Subarea is shown on Figure 3-1. The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Estrella Subarea is included in Figure 3-4, which shows groundwater levels steadily declining during the period by over 70 feet. The Estrella Subarea recorded the largest decline in groundwater levels (about 50 feet) during the 1997 to 2009 period.

Figure 3-4. Estrella Subarea Composite Hydrograph and Annual Precipitation

Sub-Area Information	
Sub-Area	Estrella
Basin Name	Paso Robles

Sub-Area Well Records	
Period of Record	1967-2009
Num. BMO Wells	6

Report Information	
Report Start Year	1981
Period of Record	1981-2009

Raingage Information	
Raingage Name	Atas. Mutual Water # 34
Raingage Elev.	835.00 ft

Raingage Records	
Period of Record	1967-2009
Average Precip.	17.64 in

Trend Analysis Results	
BMO Departure[1]	(69.00 ft)
2009 Departure	(75.48 ft)

NOTES: 1) BMO Cumulative Departure Since 1981

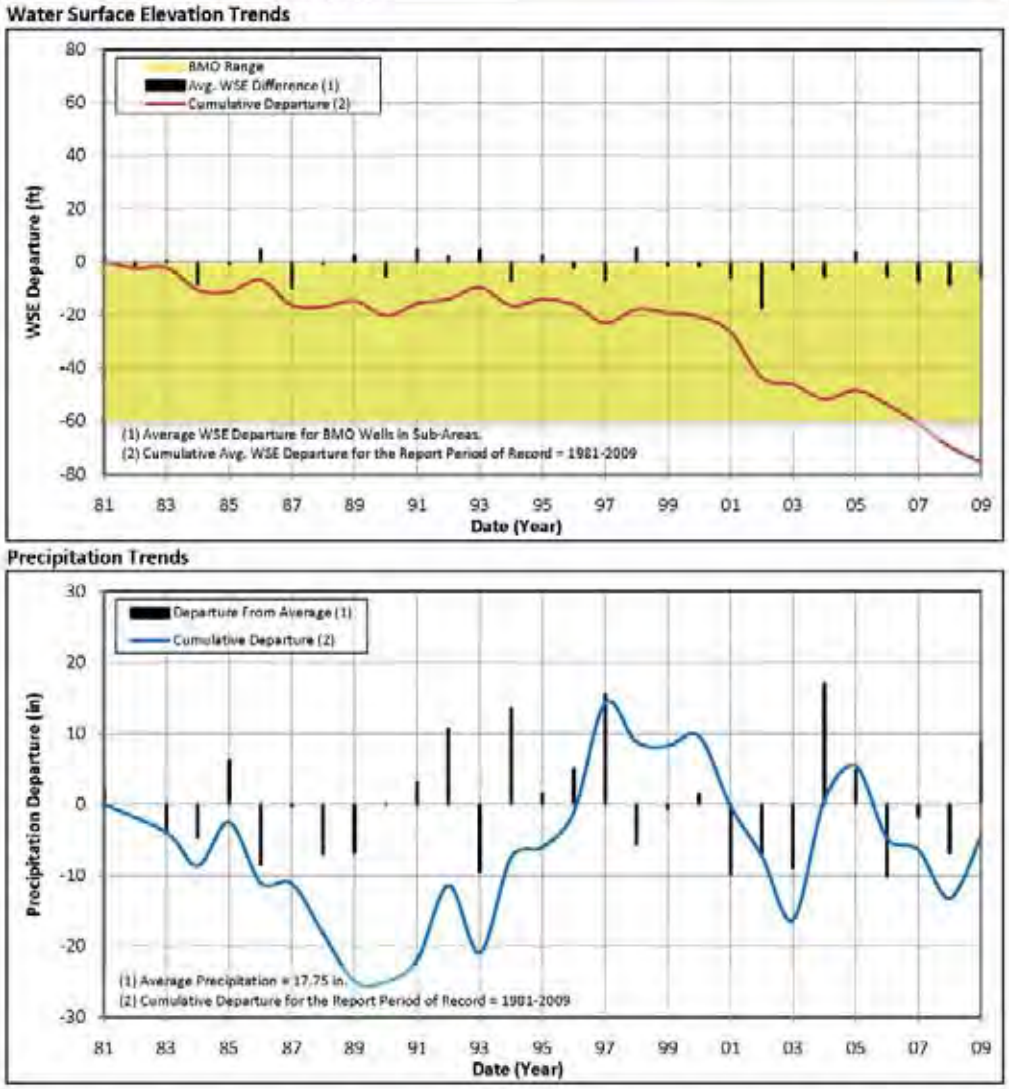


Table 3-4 presents the changes in BMO groundwater levels in the Estrella Subarea since 2008. In 2008, the composite BMO groundwater level decreased by 8.6 feet resulting in a cumulative groundwater level decline of 69.7 feet since 1981 (9.7 feet below the BMO level). In 2009, the composite BMO groundwater level decreased by 5.7 feet resulting in a cumulative groundwater level decline of 75.4 feet since 1981 (15.4 feet below the BMO level).

At this time, groundwater levels in the Estrella Subarea are below the established BMO level, and have dropped for the last two years.

Table 3-4. Changes BMO Groundwater Levels in the Estrella Subarea

Period	Annual Change (feet)	Cumulative Change Since 1981 (feet)	Comparison of Cumulative Change to BMO Level (feet)
BMO Groundwater Level			**-60**
2008 Observed Level	-8.6	-69.7	-9.7
2009 Observed Level	-5.7	-75.4	-15.4

3.5 North Gabilan Subarea

There is limited groundwater level data available, and no data that could be used to represent the average groundwater levels in the North Gabilan subarea. Additionally, there are no identified groundwater problems or issues that have been presented to the Groundwater Advisory Committee. Because of the limited available data and identification of groundwater issues in the subarea, it is not practical to identify BMOs that can be measured at this time.

3.6 San Juan Subarea

The location of the four wells identified to be representative of changes in groundwater level conditions in the San Juan Subarea is shown of Figure 3-1. The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the San Juan Subarea is included in Figure 3-5, which shows that the groundwater levels in the San Juan Subarea are highly variable on an annual basis. It appears that groundwater levels in the San Juan Subarea respond quickly to changes in hydrologic conditions, with average groundwater levels increasing or decreasing by as much as 35 feet in a single year. Overall, during the 1981 to 2009 period, average groundwater levels in the San Juan Subarea declined by about 25 feet.

Figure 3-5. San Juan Subarea Composite Hydrograph and Annual Precipitation

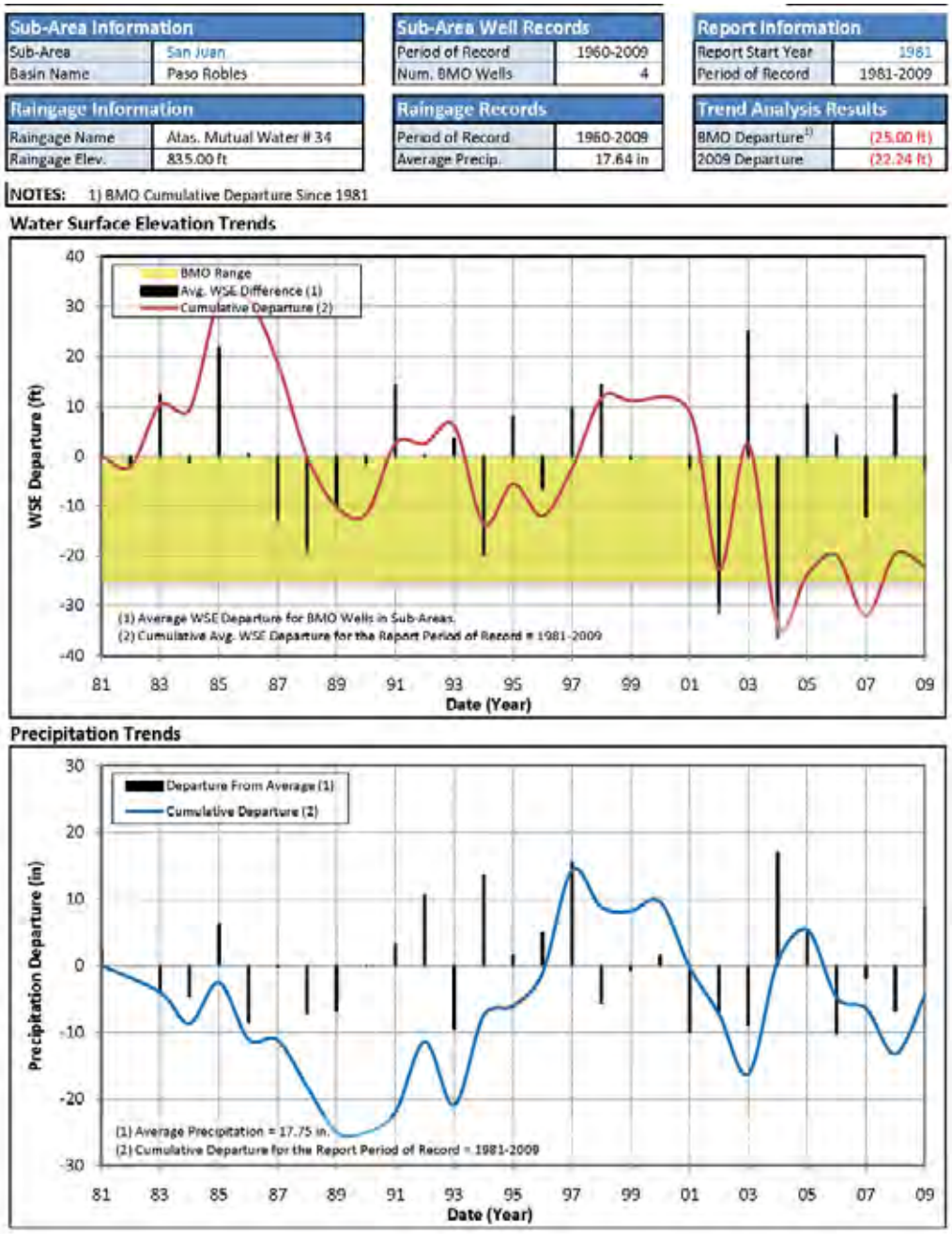


Table 3-5 presents the changes in BMO groundwater levels in the San Juan Subarea since 2008. In 2008, the composite BMO groundwater level decreased by 12.4 feet resulting in a cumulative groundwater level decline of 19.6 feet since 1981 (5.4 feet above the BMO level). In 2009, the composite BMO groundwater level decreased by 2.6 feet resulting in a cumulative groundwater level decline of 22.2 feet since 1981 (2.8 feet above the BMO level).

Since 2004, groundwater levels in the San Juan Subarea are near the established BMO level, but are not on a declining trend.

Table 3-5. Changes BMO Groundwater Levels for the San Juan Subarea

Period	Annual Change (feet)	Cumulative Change Since 1981 (feet)	Comparison of Cumulative Change to BMO Level (feet)
BMO Groundwater Level			**-25**
2008 Observed Level	12.4	-19.6	+5.4
2009 Observed Level	-2.6	-22.2	+2.8

3.7 Shandon Subarea

The location of the four wells identified to be representative of changes in groundwater level conditions in the Shandon Subarea is shown of Figure 3-1. The composite hydrograph showing the annual change and cumulative change in the average groundwater levels during the 1981 to 2009 period in the Shandon Subarea is included in Figure 3-6, which shows average groundwater levels in the Shandon Subarea declined by about 65 feet (about 2.3 feet per year), in response to a combination of increasing water demands that are met by groundwater.

Figure 3-6. Shandon Subarea Composite Hydrograph and Annual Precipitation

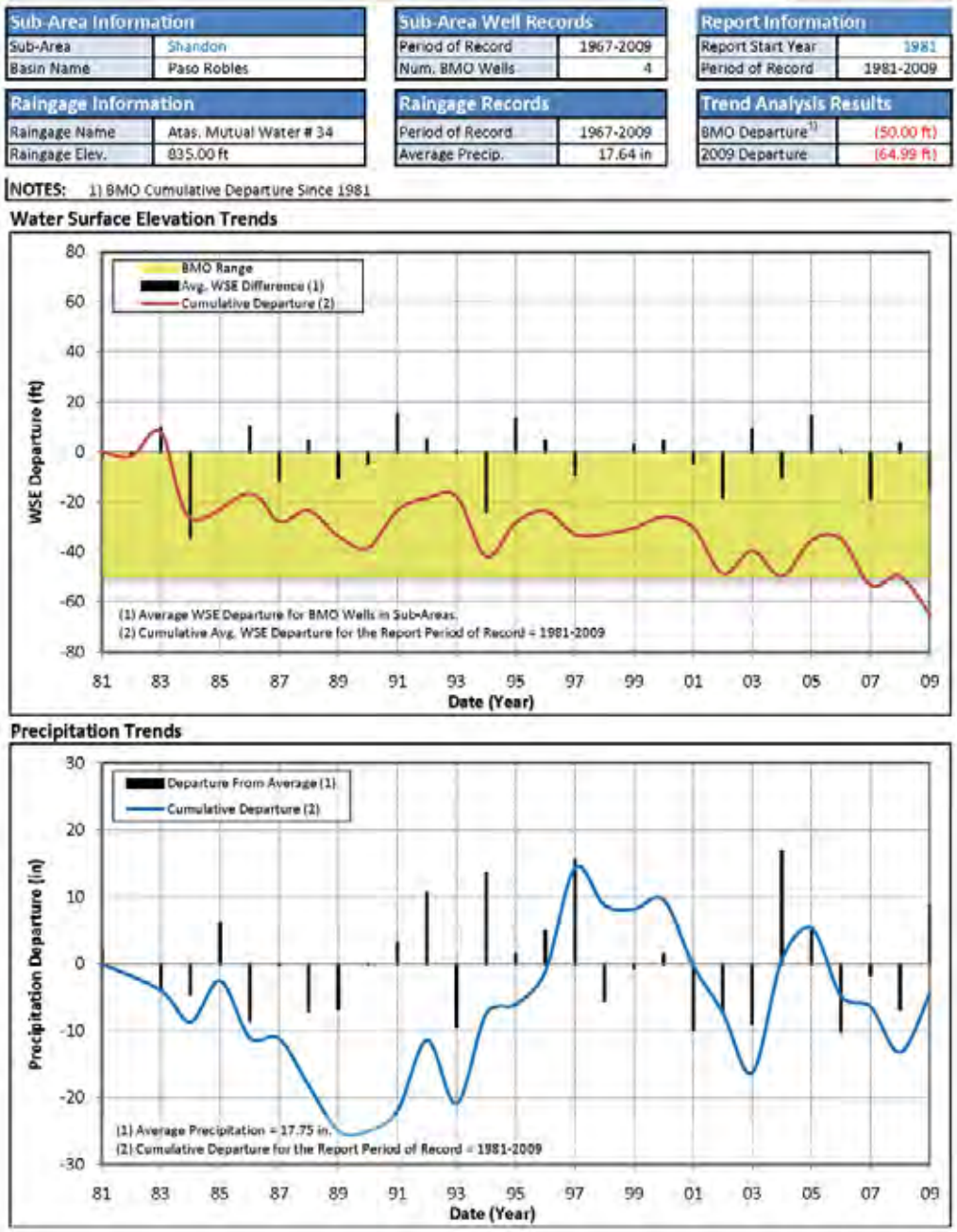


Table 3-6 presents the changes in BMO groundwater levels in the Shandon Subarea since 2008. In 2008, the composite BMO groundwater level increased by 3.6 feet resulting in a cumulative groundwater level decline of 49.7 feet since 1981 (0.3 feet above the BMO level). In 2009, the composite BMO groundwater level decreased by 15.2 feet resulting in a

cumulative groundwater level decline of 64.9 feet since 1981 (14.9 feet below the BMO level).

At this time, groundwater levels in the San Juan Subarea are below the established BMO level, and appear to be on a declining trend.

Table 3-6. Changes BMO Groundwater Levels in the Shandon Subarea

Period	Annual Change (feet)	Cumulative Change Since 1981 (feet)	Comparison of Cumulative Change to BMO Level (feet)
BMO Groundwater Level			**-50**
2008 Observed Level	3.6	-49.7	+0.3
2009 Observed Level	-15.2	-64.9	-14.9

3.8 South Gabilan Subarea

There is limited groundwater level data available, and no data that could be used to represent average groundwater levels in the subarea. Additionally, there are no identified groundwater problems or issues that have been presented to the Groundwater Advisory Committee.

Due to the limited available data and identification of groundwater issues in the subarea, it is not practical to identify BMOs that can be measured at present.

4 Status of Groundwater Management Activities

The Paso Robles Groundwater Management Plan identified over 70 Groundwater Management Activities (GMAs) that may be implemented over time to help meet the identified Basin Management Objectives. The complete list of GMAs is included in the Plan (see Table 7-1). Table 4-1 identifies the currently active GMAs. It includes the GMAs that were developed or active during the development of the Plan and identifies the activities that are anticipated to be undertaken in calendar year 2011.

The Plan included a variety of actions that are required by the Water Code, recommended by DWR Bulletin 118 California's Groundwater (DWR, 2003), and identified as optional programs under the Water Code. In the Plan, these actions are grouped into the following groundwater management components.

1. Stakeholder Involvement and Coordination
2. Groundwater Monitoring and Data Collection
3. Groundwater Resource Protection
4. Groundwater Sustainability
5. Water Management

The GMAs listed on Table 4-1 are identified by number corresponding to the groundwater management components identified in the Plan.

Table 4-1. Current Groundwater Management Activities

Groundwater Management Activity	Accomplishments during Development of Groundwater Management Plan	Anticipated Activities for Calendar Year 2011
1.2 - Formation of Implementation GAC	Formed Steering Committee to direct implementation of Groundwater Management Plan	Develop Steering Committee Meeting schedule for 2011 and Plan implementation
1.3 – Coordinate with Resource Capacity Study	Resource Capacity Study for Paso Robles Basin Certified by San Luis Obispo County Board of Supervisors in February 2011	• The San Luis Obispo County Planning Department is expected to develop schedule for implementing the land use actions identified in RCS
2.1 – Groundwater Elevation Monitoring	• San Luis Obispo County Flood Control and Water Conservation District was identified as monitoring entity for groundwater basins in County for the California Statewide Groundwater Elevation (CASGEMs) Program • Groundwater level data through 2009 used to support development of the Plan and the Basin Management Objectives	• Report 2011 groundwater levels to DWR as part of CASGEMs Program • Prepare Annual Monitoring Report for Calendar Year 2010 • Identify opportunities to expand groundwater level monitoring network • Identify opportunities to begin development of a dedicated groundwater level monitoring network • Identify new wells to become part of groundwater level monitoring program (as needed)
2.2– Groundwater Quality Monitoring	Groundwater quality data for the basin is provided to San Luis Obispo County Department of Public Works by water system operators within the County.	Continue to monitor water quality trends in the Basin.
2.4– Data Management System	• Develop tool to extract and present groundwater level data from County groundwater level database	
2.5– Project Reporting	• Prepare Annual Monitoring Report for Calendar Year 2009 • Establish annual reporting format	• Prepare Annual Monitoring Report for Calendar Year 2010
4.1 – Replenishment of Groundwater	• Continue efforts to deliver Nacimiento Project Water to the water users in the Paso Robles Groundwater Basin	• Continue efforts to deliver Nacimiento Project Water to the water users in the Paso Robles Groundwater Basin • Explore opportunities for unassigned Nacimiento Project Water

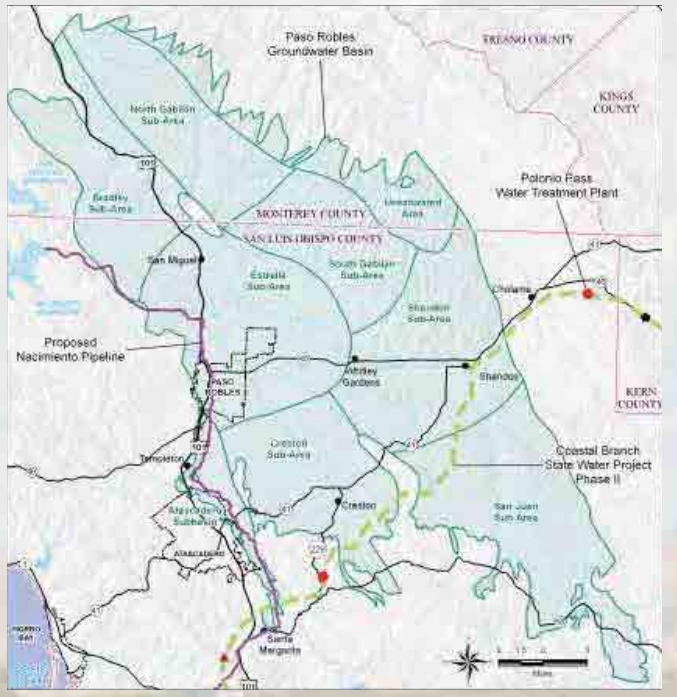
5.1 – Agricultural Water Management Practices	• Continuation of the UC Extension Study on vineyard irrigation practices • Paso Robles Wine Country Alliance (PRWCA) represents member vineyard during development of GMP, including serving on the Steering Committee for Plan implementation	• Continuation of the UC Extension Study on vineyard irrigation practices • Continue to encourage implementation of best management practices amount vineyard owners • Ensure new wineries use best management practices consist with BMP's identified in RCS
5.2 – Urban Water Management Practices	• Urban water purveyors continue to implement water conservation BMPs	• Continue to implement water conservation and demand management programs
5.3 – Rural Residential Water Management Practices	• Rural residential stakeholders participate in development of Groundwater Management Plan	• Revise Growth Management Ordinance to limit yearly non-agricultural development in rural areas of the Basin • County will develop a landscape ordinance to limit the amount of turf and other high-water use features on parcels.

Appendix G Stakeholder Involvement Documentation

Introducing

The Paso Robles Groundwater Basin Management Plan

San Luis Obispo County recently completed an Integrated Regional Water Management Plan. The plan contains groundwater monitoring and management objectives for the groundwater basins in the County, including the Paso Robles Groundwater Basin. In response to these objectives, The City of Paso Robles and San Luis Obispo County are leading the preparation of a groundwater management plan (GMP) for the Paso Robles Groundwater Basin. The GMP will address groundwater conditions, identify local and basin-wide groundwater issues, and outline measures to protect groundwater resources within the plan area (shown at right).



A Project Kickoff Meeting will be held:

Thursday, January 15, 2009
5 p.m. — 7 p.m
City of Paso Robles
Emergency Operations Center
900 Park Street

The meeting will include a review of the project purpose, approach, and schedule. Additionally, the formation of the Groundwater Advisory Committee will be discussed. The purpose of the Groundwater Advisory Committee is to assist in developing the GMP. The draft GMP is scheduled to be released in July 2009, with the final GMP due December 2009.

Parties interested in the GMP are encouraged to participate in the planning process by attending public meetings scheduled by the Groundwater Advisory Committee.

Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

Meeting No. 1 - January 15, 2009

Name	Affiliation/ Group	Sub-area	Interested as Sub-area Representative (yes/no)	Phone Number	Email
John Neil	Atascadero Mutual Water Co.		yes	805 461 7217 x 21	jneil@amwc.us
JAY SHORT	TEMPLETON CSD		YES	805-434-4907	UTILITIES@TEMPLETONCSD.ORG
ROBERT JOHNSON	MONTEREY COUNTY WATER RESOURCES AGENCY		YES	831.755.4860	johnsonr@co.monterey.ca.us
Jeremy Howard				805.226.9984	jahoward@alumni.calpoly.edu
Duane Picanco	Paso Robles City		yes	805-227-7212	drpicanco@pncity.com
Joy Fitzhugh	SLO Co Farm Bureau		Yes	805-543-3654	joy@slofarmbureau.org
RAY ALLEN	SLO Co CATTLEMEN	ESTRELLA	YES	805-239-2540	RAYANDMIKE@q-mail.com
Steve Sinta	PRIOR	San Juan	Yes	238-9495	sjsinta@earthlink.net
Paul Sorensen	Fugro	—	—	805-542-0797	psorensen@fugro.com
Shayna Bailey	HS-LT RCD			434-0396 x4	shaynarcd@hotmail.com
BLAIR ZAJAC	IGGPRA			226-9010	bZAJAC@TCSN.NET
Walt Hee				239-2228	
Bob Roos	Nacimiento Water Forum		Yes	466-6561	broos@fix.net
Mike Kelley	Green River MWC	Shandon	Yes	805 423 2026	mkelleyp@sbcglobal.net
Mike Steinbock	" "	"	"	805 434-3142	h2omike7148@hotmail.com
DENNIS BOWMAN	GREEN RIVER MWC	SHANDON	YES	805 610 8338	DLBOWMAN@TCSN.NET
Michael Stephens	AMWC		NO	805 461 7217 x 31	mstephens@amwc.us

Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

Meeting No. 1 - January 15, 2009

Name	Affiliation/ Group	Sub-area	Interested as Sub-area Representative (yes/no)	Phone Number	Email
KATHY BARNETT	RESIDENT PASO ROBLES				
Sue Luft	WRAC	Creston	yes	227-4785	asluft@wildblue.net
Sheila Lyons	Creston Advisory Body (CAB)	Creston	—	—	salyons@airspeedwireless.net
David Lyons	CAB	Creston	—	—	delyon@airspeedwireless.net
Della Barrett	Private	South Atascadero	?	461-1420	mustang4della@aol.com
Kathy Sweers	Private	South Atascadero	—	466-2959	—
Dave + Debra Compton	Private	Estrella	Yes	467-3158	debraCompton@gmail.com
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Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

Meeting No. 1 - January 15, 2009

Name	Affiliation/ Group	Sub-area	Interested as Sub-area Representative (yes/no)	Phone Number	Email
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Paso Robles Groundw. r Basin Management Plan

Kickoff Meeting

Meeting No. 2 - November 12, 2009

Name	Affiliation/ Group	Sub-area	Interested as Sub-area Representative (yes/no)	Phone Number	Email
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Paso Robles Groundw. r Basin Management Plan

Kickoff Meeting

Meeting No. 2 - November 12, 2009

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Paso Robles Groundw. .r Basin Management Plan

Kickoff Meeting

Meeting No. 2 - November 12, 2009

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Paso Robles Groundw. r Basin Management Plan

Kickoff Meeting

Meeting No. 2 - November 12, 2009

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Paso Robles Groundw. Basin Management Plan

Groundwater Advisory Committee

Meeting No. 3- February 25, 2010

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Paso Robles Groundw. . Basin Management Plan

Groundwater Advisory Committee

Meeting No. 3- February 25, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - May 10, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - May 10, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - May 10, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - May 10, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - May 10, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - April 19, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - April 19, 2010

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Paso Robles Groundwater Basin Management Plan
Workshop on Basin Management Objectives and Management Activities
Stakeholder Participation Sheet
(April 19, 2010)

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - April 19, 2010

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Paso Robles Groundwater Basin Management Plan

BMO Workshop - April 19, 2010

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Paso Robles Groundw . Basin Management Plan

Groundwater Advisory Committee

Meeting No. 4 - August 2, 2010

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Paso Robles Groundw . Basin Management Plan

Groundwater Advisory Committee

Meeting No. 4 - August 2, 2010

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Paso Robles Groundw : Basin Management Plan

Groundwater Advisory Committee

Meeting No. 4 - August 2, 2010

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Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

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Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

Meeting No. 5- December 2, 2010

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Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

Meeting No. 5- December 2, 2010

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Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

February 10, 2011

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Paso Robles Groundwater Basin Management Plan

Groundwater Advisory Committee

February 10, 2011

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Water Quality Control Plan

for the

Central Coastal Basin

June 2011

Regional Water Quality Control Board, Central Coast Region
State Water Resources Control Board
California Environmental Protection Agency

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Matt Rodriquez, Secretary, California Environmental Protection Agency

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Water Quality Control Plan

for the

Central Coastal Basin

June 2011

(Including Amendments Effective Through June 8, 2011)

This report was prepared under the direction of:

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by

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Regional Water Quality Control Board, Central Coast Region
State Water Resources Control Board
California Environmental Protection Agency

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CHAPTER 1. INTRODUCTION

I. FUNCTION OF THE WATER QUALITY CONTROL PLAN (BASIN PLAN)

The objective of this Water Quality Control Plan for the Central Coastal Basin, or Basin Plan, is to show how the quality of the surface and ground waters in the Central Coast Region should be managed to provide the highest water quality reasonably possible. Water uses and water benefits vary. Water quality is an important factor in determining use and benefit. For example, drinking water has to be of higher quality than the water used to irrigate pastures. Both are legitimate uses, but the quality requirements for irrigation are different from those for domestic use. The plan recognizes such variations.

This Basin Plan lists the various water uses (Beneficial Uses, Chapter Two). Second, it describes the water quality which must be maintained to allow those uses (Water Quality Objectives, Chapter Three). Federal terminology is somewhat different, in that beneficial uses and water quality objectives are combined and the combination is called Water Quality Standards. Chapter Four, the Implementation Plan, then describes the programs, projects, and other actions which are necessary to achieve the standards established in this plan. Chapter Five, Plans and Policies, summarizes State Water Resources Control Board (State Board) and Regional Water Quality Control Board (Regional Board) plans and policies to protect water quality. Chapter Six describes statewide surveillance and monitoring programs as well as regional surveillance and monitoring programs.

The Regional Board implements the Basin Plan by issuing and enforcing waste discharge requirements to individuals, communities, or businesses whose waste discharges can affect water quality. These requirements can be either State Waste Discharge Requirements for discharges to land, or federally delegated National Pollutant Discharge Elimination System (NPDES) permits for discharges to surface water. Methods of treatment are not specified. When such discharges are managed so that: 1) they meet these requirements; 2) water quality objectives are met; and, 3) beneficial uses are protected, water quality is controlled.

The Basin Plan is also implemented by encouraging water users to improve the quality of their water supplies, particularly where the wastewater they discharge is likely to be reused. Public works or other projects which can affect water quality are reviewed and their impacts identified. Proposals which implement or help achieve the goals of the Basin Plan are supported; the Regional Board makes water quality control recommendations for other projects.

II. LEGAL BASIS AND AUTHORITY

California's Porter-Cologne Water Quality Control Act (1969), which became Division Seven ("Water Quality") of the State Water Code, establishes the responsibilities and authorities of the nine Regional Water Quality Control Boards (previously called Water Pollution Control Boards) and the State Water Resources Control Board (SWRCB). The Porter-Cologne Act names these Boards "... the principal State agencies with primary responsibility for the coordination and control of water quality" (Section 13001). Each Regional Board is directed to "...formulate and adopt water quality control plans for all areas within the region." A water quality control plan for the waters of an area is defined as having three components: beneficial uses which are to be protected, water quality objectives which protect those uses, and an implementation plan which accomplishes those objectives (Section 13050). Further, "such plans shall be periodically reviewed and may be revised" (13240). The federal Clean Water Act (Public Law 92-500, as amended) provides for the delegation of certain responsibilities in water quality control and water quality planning to

the states. Where the Environmental Protection Agency (EPA) and the SWRCB have agreed to such delegation, the Regional Boards implement portions of the Clean Water Act, such as the NPDES program and toxic substance control programs.

The Porter-Cologne and Clean Water Acts also describe how enforcement of waste discharge regulations is to be carried out. Enforcement tools available to the Regional Board range from simple letters to the discharger, through formal Regional Board order, and direct penalty assessments, to judicial abatement for civil and/or criminal penalties. Legally noticed public hearings are required for most actions, but some enforcement actions (e.g., Cleanup or Abatement Orders) have been delegated to staff to allow for a quicker response than regularly scheduled Regional Board meetings can provide.

III. THE CENTRAL COASTAL REGION

One of nine Regional Water Quality Control Boards in California, the Central Coast Regional Board has jurisdiction over a 300-mile long by 40-mile wide section of the State's central coast. Its geographic area encompasses all of Santa Cruz, San Benito, Monterey, San Luis Obispo, and Santa Barbara Counties as well as the southern one-third of Santa Clara County, and small portions of San Mateo, Kern, and Ventura Counties. Included in the region are urban areas such as the Monterey Peninsula and the Santa Barbara coastal plain; prime agricultural lands as the Salinas, Santa Maria, and Lompoc Valleys; National Forest lands, extremely wet areas like the Santa Cruz mountains; and arid areas like the Carrizo Plain. Figure 1-1 shows the Central Coast Regional boundary. Some physical characteristics of the Region are listed below:

CENTRAL COAST REGION[1]

CHARACTERISTICS	NUMBER	MEASURE
Area of Region	--	11,274 square miles
Streams	Unknown	2,360 miles
Lakes	99	25,040 acres
Ground Water Basins	53	3,559 square miles
Mainland Coast	--	378 miles
Wetlands and Estuaries	59	8,387 acres
Areas of Special Biological Significance	9	235,825 acres

1 Water Quality Assessment for Water Years 1986 and 1987, Water Quality Monitoring Report No. 88-1 Water Quality, Division of Water Quality, State Water Resources Control Board, July, 1988.

Topographic features are dominated by a rugged seacoast and three parallel ranges of the Southern Coast Mountains. Ridges and peaks of these mountains, the Diablo, Gabilan, and Santa Lucia Ranges, reach to 5,800 feet. Between these ranges are the broad valleys of the San Benito and Salinas Rivers. These Southern Coast Ranges abut the west to east trending Santa Ynez Mountains of the Transverse Ranges that parallel the southern exposed terraces of the Santa Barbara Coast.

This coastal area includes urbanized and agricultural areas along Monterey Bay, the rugged Big Sur Coast, Morro Bay with its famous rock, the sandy clam beds of Pismo Beach, and a varied coastline south to Point Conception and eastward along the terraces and recreational beaches which line the Santa Barbara Channel. The inland valleys and cities reflect an agricultural, oil, and tourism economy, as well as the early history of California expressed in the architectural styles of the famous Spanish missions which are found throughout this region.

The trend of the mountain ranges, relative to onshore air mass movement, imparts a marked climatic contrast between seacoast, exposed summits, and interior basins. Variations in terrain, climate, and vegetation account for a multitude of different landscapes. Seacliffs, sea stacks, white beaches, cypress groves, and redwood forests along the coastal strand contrast with the dry interior landscape of small sagebrush, short grass, and low chaparral.

In times past, the beaches and ocean waters offshore have been prolific producers of clams, crustaceans, and important sport and commercial

Figure 1-1. Central Coast Region 3

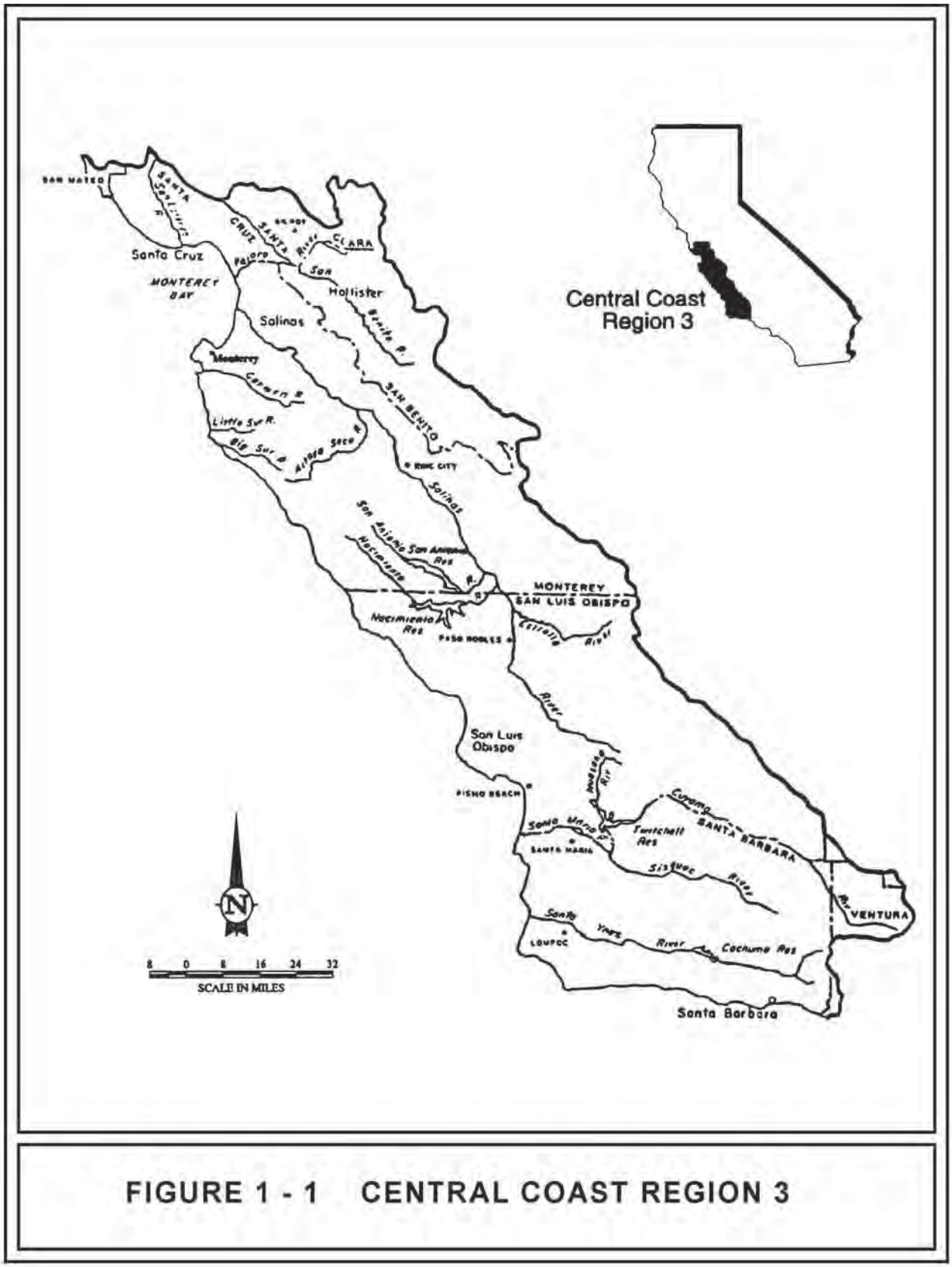

FIGURE 1 - 1 CENTRAL COAST REGION 3

fish. Past fishing practices and disruption of habitat have reduced fishery resources; protective controls are now in effect. Terrestrial wildlife includes a wide range of valley and upland species including the more common raccoon, quail, bear, and deer. Rare, endangered, or unique species include various shore birds, the Morro Bay Kangaroo rat, the European boar, and the California condor. The Sespe Condor Range serves as a sanctuary for this impressive bird.

Historically, the economic and cultural activities in the basin have been agrarian. Livestock grazing persists, but it has been combined with hay cultivation in the valleys. Irrigation, with pumped local ground water, is very significant in intermountain valleys throughout the basin. Mild winters result in long growing seasons and continuous cultivation of many vegetable crops in parts of this basin.

While agriculture and related food processing activities are major industries in the region, oil production, tourism, and manufacturing contribute heavily to its economy. The northern part of the region has experienced a significant influx of electronic manufacturing industry, and the southern part is being heavily influenced by expanded offshore oil exploration and production.

The Central Coast Region has three times the volume of average annual precipitation (12,090,000 acre-feet) as the Los Angeles Region, but one-seventh the population (1.2 million versus 8 million). The North Coast Region receives 52 million acre-feet of precipitation on the average with a population of 460,000. These three regions demonstrate the range of California's water and population distribution imbalance:

Region	Annual Average Precipitation (Ac. Ft.) per Person
North Coast	113.0
Central Coast	9.9
Los Angeles	0.56

Although this table shows the Central Coast is somewhat in the middle of the State's water-versus-population distribution, the region is considered arid for the most part. An exception is the Santa Cruz mountain area with its relatively high average precipitation.

Total population of the region is estimated to be 1.22 million people. San Luis Obispo County continues to grow more rapidly than other large counties in the region. The population of San Luis Obispo County has doubled since 1970:

CENTRAL COAST REGION POPULATION

County	1970	1988
Santa Cruz	124,000	225,400
Santa Clara (South)	29,000	65,800
San Benito	18,000	34,100
Monterey	249,000	346,100
San Luis Obispo	107,000	204,300
Santa Barbara	265,000	345,000
Total[1]	792,000	1,220,700

1 Table does not include relatively small populations of portions of Ventura, Kern, and San Mateo Counties that are within the Central Coast Region.

Adequate quality water for many beneficial uses in the Central Coastal Basin is in short supply. Water rationing for domestic purposes is seriously considered and sometimes implemented during water shortages. The use of water by the human population and its activities is increasing in the basin. Water mining and seawater intrusion have resulted in some locations. Consequently, the competition for waters of adequate quality will become more intense in the future.

Water quality problems most frequently encountered in the Central Coastal Basin pertain to excessive salinity or hardness of local ground waters. Ground water basins containing 1000 mg/l Total Dissolved Solids (TDS) or higher are found near Hollister, the Lower Forebay of the Salinas Sub-basin, the Carrizo Plain, the Santa Maria and Cuyama Valleys, San Antonio Creek Valley, Lompoc and Santa Rita Basins of the Santa Ynez River Valley, and Goleta and Santa Barbara. The Carrizo Plain ground waters are most highly mineralized -- averaging over 5,000 mg/l TDS. Increasing nitrate concentrations is a growing problem in the Salinas River Basin, Los Osos Creek Basin, the Santa Maria Valley, and near Arroyo Grande. Surface water problems are less frequently evident, although bacteriological contamination of coastal waters has been a problem in Morro Bay and South Santa Barbara County. Eutrophication occurs in Pajaro River and Llagas Creek, Salinas River

below Spreckels, and in the lower reaches of San Luis Obispo Creek. Some streams in the basin are naturally highly mineralized and contribute to the excessive salinity of local ground waters; examples include Pancho Rico Creek in the Salinas River Sub-basin, and the Cuyama River in the Santa Maria Sub-basin. Both surface waters contain in excess of 1000 mg/l TDS.

IV. THE REGIONAL BOARD

The Regional Board consists of nine members appointed by the Governor to serve staggered four-year terms. Members must reside or maintain a place of business within the Region and must be associated with or have special knowledge of specific activities related to the control of water quality. Members of the Regional Board conduct their business at regular meetings and public hearings at which public participation is encouraged.

All duties and responsibilities of the Regional Board are directed at providing reasonable protection and enhancement of the quality of all waters in the Region, both surface and underground. The programs by which these duties and responsibilities are carried out include:

- Preparing new or revised policies addressing region-wide water quality concerns;
- Adopting, monitoring compliance with, and enforcing waste discharge requirements and NPDES permits;
- Providing recommendations to the State Board on financial assistance programs, proposals for water diversion, budget development, and other statewide programs and policies;
- Coordinating with other public agencies which are concerned with water quality control; and
- Informing and involving the public on water quality issues.

V. HISTORY OF BASIN PLANNING AND THE BASIN PLAN

Prior to 1970, the Regional Board did not have an active water quality planning function. Water quality problems in surface streams and ground water were responded to by setting controls on discharges. Those discharge controls generally consisted of limiting the allowable increases in TDS concentrations and certain other parameters. Normally, the only additional requirement specified by the Regional Board was that the discharge could not create a nuisance or pollution.

At the request of the federal Water Quality Administration, predecessor to the EPA (and successor to the federal Water Pollution Control Administration), the so-called 1967 Standards were developed and published. These standards applied to coastal and estuarine waters .

By 1970, the Regional Board was actively involved in the formulation of plans to meet established water quality objectives. The federal Clean Water Act and the Porter-Cologne Act, requiring basinwide planning in order to qualify for state and federal funding, plus the National Pollution Discharge Elimination System (NPDES), which empowers the states to set discharge standards, placed new tools in the hands of the Regional Boards and encouraged the development of new approaches to water quality management.

The first single plan for this Region was the 1971 Interim Water Quality Control Plan. It represented significant progress in that the 1967 Standards were incorporated and standards were designated for fresh water streams as well.

Following adoption of the 1971 Interim Plan, the State Board developed and adopted the Ocean Plan and the Thermal Plan. The Regional Board expanded objectives for municipal and domestic water supplies. Chemical objectives for the San Lorenzo River Sub-basin were made more stringent. Incorporation of these State Board plans and Regional Board revisions produced the Revised Interim Water Quality Control Plan of 1973.

Work then began in earnest on a complete Water Quality Control Plan, the 1975 Basin Plan, which has been the foundation of the Regional Board's planning operations since its adoption in 1975. Basin Plans were being developed statewide at that time under the direction of the State Water Resources Control Board (SWRCB). In this region, the prime contractors for basin planning were Brown and Caldwell Consulting Engineers; Water Resources Engineers, Inc.; and Yoder, Trottner, Orlob and Associates. Water quality objectives were based largely on existing water quality.

After adoption of the 1975 Basin Plan, some thirty-eight amendments were made to the Basin Plan. Management of those amendments became cumbersome and led to the need for a Basin Plan reprint which included all current amendments. This document is intended to fulfill that need.

VI. TRIENNIAL REVIEW AND BASIN PLAN AMENDMENT PROCEDURE

The federal Clean Water Act (Section 303(c)) requires states to hold public hearings for review of water quality standards at least once every three years. Water quality standards consist of beneficial use designations and water quality criteria (objectives) necessary to protect those uses. The Porter-Cologne Water Quality Control Act requires the entire Basin Plan to be reviewed periodically. While a major part of the review process consists of identifying potential problems, an important part of the review is the reaffirmation of those portions of the plan where no potential problems are identified.

At the conclusion of the triennial review public hearing, Regional Board staff prepares a priority list of potential problems to the Basin Plan that may result in amendments. Placing a potential problem on the priority list will only require the Regional Board staff to investigate the need for an amendment. It does not necessarily mean a revision of the water quality control plan will be made.

Other items completed after the public hearing include:

- Detailed workplans of each issue;
- Regional Board identification of issues that can be completed within existing resource allocations over a three-year period; and
- List of issues requiring additional resources to complete.

Once the triennial review process is complete, Regional Board staff begin investigating the issues in order of rank. After each investigation, staff determines the need for a Basin Plan amendment.

Basin Plan amendments can also occur for issues not identified during the triennial review. Amendments can occur for urgent issues to reflect new legislation.

Basin Plan amendment hearings are advertised in the public notice section of a newspaper circulated in areas affected by the amendment. Persons interested in a particular issue can also notify the Regional Board staff of their interest in being notified of hearings on that topic.

Basin Plan amendments do not become effective until approved by the State Board. Surface water standards also require the approval of the Environmental Protection Agency to become effective.

VI.A. CONTINUING PLANNING

The Basin Plan is a flexible tool which must be reviewed and revised regularly for it to adapt to changing conditions. "Continuing planning" allows this to occur. The following section prioritizes Regional Board tasks and resources. This ranked list is referred to as the "Triennial Review List" and is shown in Table 1-1.

Items listed were ranked in order of priority by the Regional Board on May 6, 1988 and July 8, 1988. Each item is followed by an estimate of staff time needed to complete the item (actual time and duration). For those items requiring contract funding, estimated contract needs are identified following the description of each item. Resolution of these items may result in future Basin Plan amendments.

Table 1-1. 1988 Triennial Review Priority List

Task	Estimated Time Staff Resources (Staff Years and Duration)
1. Adopt water quality limited segments*	0.02 SY
2. Reprint Basin Plan*	0.2 SY 1 year
3. Incorporate Proposition 65 criteria as developed by State Board	0.2 SY 6 months
4. Determine water quality monitoring needs*	0.4 SY
5. Establish nutrient objectives for Pajaro River and Llagas Creek Contract $ = 40,000	0.3 SY 20 months
6. Establish nutrient objectives for San Luis Obispo Creek Contract $ = 10,000	0.3 SY 20 months
7. Establish additional toxic pollutant objectives as developed by the State Water Resources Control Board	0.1 SY 5 years
8. Reevaluate Santa Maria Basin ground water quality objectives (including Nipomo Mesa and Valley) Contract $ = 20,000	0.3 SY 2 years
9. Reevaluate discharge prohibition to Santa Maria River below Highway One Bridge Contract $ = 20,000	0.2 SY 2 years
10. Revaluate Lompoc Plain Boron objective*	0.03 SY
11. Incorporate State Board Ground Water Strategy and Develop Regional Ground Water Strategy	0.3 SY 3 years
12. Reevaluate San Lorenzo River nitrate objective Contract $ = $30,000	0.4 SY 2 years
13. Review on-site sewage disposal prohibition in San Lorenzo Valley Class I & II areas	0.2 SY
14. Review beneficial uses for: Santa Barbara Harbor (shellfish), Goleta Slough (migration and spawning), San Luis Obispo Creek (municipal water supply), Lower Salinas River (all)	0.7 SY
15. Develop Upper Salinas Valley ground water salt management plan Contract $ = 30,000	0.4 SY 1 year
16. Adopt amendments for water bodies affected by toxics as required by Clean Water Act	0.2 SY
17. Develop toxic control strategy	0.3 SY
18.	
a. Develop beneficial uses for additional needed water bodies	0.2 SY
b. Add "Preservation of Areas of Special Biological Significant" (BIOL) beneficial use to needed water bodies	0.05 SY
19. Determine need for septic tank prohibition in Prunedale, San Lucas, Los Olivos, Ballard and other needed areas	1.0 SY
20. Establish septic tank sludge policy	0.2 SY
21. Establish residual repositories policy	0.3 SY
22. Establish Gilroy, Morgan Hill, San Martin ground water management plan	0.4 SY 8 months
23. Establish nonpoint source runoff policy for sensitive watersheds (i.e. Elkhorn Slough)	0.5 SY 1 year
24. Establish agriculture/ pesticide runoff policy	0.2 SY
25. Establish greenhouse operations policy	0.1 SY
26. Evaluate erosion/sedimentation problems in Santa Cruz County	0.4 SY
27. Reevaluate vessel discharge policy	0.2 SY
28. Reevaluate Santa Ynez ground water basin objective	0.3 SY 6 months
29. Provide guidance for effluent limits in areas with high background concentrations (e.g. ground water nitrate exceeds objectives)	0.2 SY
30. Establish suitable criteria for Waste Discharge Requirements (e.g. standardize rainfall event used to evaluate capacity)	0.2 SY
31. Provide guidance for regulation of point source discharges in the vicinity of significant nonpoint source discharges	0.2 SY
32. Review unionized ammonia objective for receiving waters	0.4 SY
33. Reevaluate nonpoint source controls for urban and rural runoff	0.3 SY
34. Establish storm water discharge policy	0.5 SY
35. Review cumulative impact of Monterey Bay discharges. Determine need for policy	0.4 SY
36. Establish policy for discharge of high temperature waters to ground water	0.2 SY
37. Incorporate revised ground water basin boundary maps*	0.2 SY
38. Review cumulative impact of future on-site disposal on Nipomo Mesa/Valley. Reevaluation of the Nipomo prohibition boundaries	0.4 SY
39. Establish oil drilling mud policy	0.2 SY
40. Establish Morro Basin ground water objectives	0.5 SY
41. Establish ground water objectives for San Benito Basin Contract $ = 40,000	0.5 SY 2 years

Table 1-1. 1988 Triennial Review Priority List

Task	Estimated Time Staff Resources (Staff Years and Duration)
42. Establish ground water objectives for Price Canyon-Edna Valley Watershed Contract $ = $20,000	0.3 SY 18 months
43. Establish offshore oil policy	0.1 SY
44. Establish reclamation/conservation policy	0.05 SY
45. Evaluate need for sewering Hidden Glen area of Scotts Valley	0.2 SY
46. Review water contact recreation for San Miguel, Santa Rosa, and Santa Cruz Island	0.05 SY
47. Update landfill policy to incorporate new State standards*	0.05 SY
48. Update dairy waste policy to incorporate new State standards*	0.05 SY
49. Delete Mission Canyon and Los Alamos prohibition areas*	0.05 SY

* These tasks accomplished by adoption of this Basin Plan

CHAPTER 2. PRESENT AND POTENTIAL BENEFICIAL USES

State policy for water quality control in California is directed toward achieving the highest water quality consistent with maximum benefit to the people of the State. Therefore, all water resources must be protected from pollution and nuisance that may occur as a result of waste discharges.

Establishing the beneficial uses to be protected in the Central Coastal Basin is a cornerstone of this comprehensive plan. Once uses are recognized, compatible water quality standards can be established as well as the level of treatment necessary to maintain the standards and ensure the continuance of the beneficial uses. This chapter will examine and identify historical, present, and potential beneficial uses in the Basin.

The remainder of this chapter summarizes current beneficial uses, describes anticipated future water demands characterizing future or potential water users, and lists the present and potential beneficial uses in tabular form.

I. PRESENT AND POTENTIAL BENEFICIAL USES

Beneficial uses are presented for inland surface waters by 13 sub-basins in Table 2-1. Beneficial uses for inland surface waters are arranged by hydrologic unit on pages II-2 through II-15. A map of the hydrologic units is shown in Figure 2-1 on page II-16. Beneficial uses are regarded as existing whether the water body is perennial or ephemeral, or the flow is intermittent or continuous. Beneficial uses of coastal waters are shown in Table 2-2 on page II-17.

Surface water bodies within the Region that do not have beneficial uses designated for them in Table 2-1 are assigned the following designations:

- Municipal and Domestic Water Supply
- Protection of both recreation and aquatic life.

Municipal and Domestic Water Supply is designated in accordance with the provisions of State Water Resources Control Board Resolution 88-63 is by reference, a part of this Plan. (A copy of this resolution is located in the appendix). These MUN designations in no way affect the presence or absence of other beneficial use designations in these water bodies.

Ground water throughout the Central Coastal Basin, except for that found in the Soda Lake Sub-basin, is suitable for agricultural water supply, municipal and domestic water supply, and industrial use. Ground water basins are listed in Table 2-3. A map showing these ground water basins is displayed in Figure 2-2 on page II-19.

II. BENEFICIAL USE DEFINITIONS

Beneficial uses for surface and ground waters are divided into the twenty standard categories listed below. One of the principal purposes of this standardization is to facilitate establishment of both qualitative and numerical water quality objectives that will be compatible on a statewide basis.

Municipal and Domestic Supply (MUN) - Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply. According to State Board Resolution No. 88-63, "Sources of Drinking Water Policy" all surface waters are considered suitable, or potentially suitable, for municipal or domestic water supply except where:

a. TDS exceeds 3000 mg/l (5000 uS/cm electrical conductivity);
b. Contamination exists, that cannot reasonably be treated for domestic use;
c. The source is not sufficient to supply an average sustained yield of 200 gallons per day;

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
BIG BASIN HYDROLOGIC UNIT																						
Lucerne Lake Estuary						X	X	X	X			X	X	X	X				X			X
Lucerne Lake	X	X				X	X	X	X							X			X			
Arroyo de los Frejoles Creek	X	X			X	X	X	X	X	X	X	X	X	X		X			X			
Arroyo de los Frejoles Reservoir	X	X			X	X	X	X	X	X						X	X		X			
Gazos Creek Lagoon/Estuary						X	X	X	X	X	X	X	X	X	X				X			X
Gazos Creek	X	X			X	X	X	X	X		X	X				X			X			
Old Womans Creek	X					X	X	X	X		X	X	X						X			
Whitehouse Creek	X					X	X	X	X		X	X	X		X	X			X			
Cascade Creek Lagoon/Estuary						X	X	X	X		X	X	X	X	X				X			X
Cascade Creek	X	X			X	X	X	X	X		X	X	X	X		X			X			
Green Oaks Creek Lagoon/Estuary						X	X	X	X			X		X	X				X			X
Green Oaks Creek	X	X			X	X	X	X	X	X	X	X	X		X	X			X			
Ano Nuevo Creek	X	X			X	X	X	X	X		X	X	X	X	X	X			X			
Finney Creek	X	X				X	X	X	X				X		X	X			X			
Elliot Creek	X	X				X	X	X	X				X		X	X			X			
Waddell Creek Estuary					X	X	X	X	X		X	X	X	X	X				X			X
Waddell Creek (Main Stem)	X	X		X	X	X	X	X	X		X	X	X	X		X			X			
Waddell Creek, east branch	X				X	X	X	X	X		X	X	X	X		X			X			
Last Chance Creek	X	X			X	X	X	X	X		X	X		X					X			
Blooms Creek	X				X	X	X	X	X			X	X	X					X			
Sempervirens Creek	X				X	X	X	X	X		X	X	X						X			
Union Creek	X					X	X	X	X				X						X			
Sempervirens Res.	X					X	X	X	X				X			X			X			X
Opal Creek	X				X	X	X	X	X				X						X			
Rogers Creek	X					X	X	X	X				X						X			
Maddocks Creek	X					X	X	X	X				X						X			
Waddell Creek, west branch	X				X	X	X	X	X		X	X	X	X					X			
Kelley Creek	X				X	X	X	X	X										X			
Berry Creek	X				X	X	X	X	X										X			
Henry Creek	X				X	X	X	X	X				X						X			
Scott Creek Lagoon						X	X	X	X		X	X		X	X				X			X
Scott Creek	X	X		X	X	X	X	X	X		X	X		X		X			X			
Little Creek	X	X		X	X	X	X	X	X		X	X		X					X			
Big Creek (Ano Nuevo)	X	X		X	X	X	X	X	X		X	X		X				X	X			
Berry Creek	X				X	X	X	X	X				X						X			
Deadman Gulch Creek	X				X	X	X	X	X			X		X					X			
Boyer Creek	X				X	X	X	X	X			X						X	X			
Mill Creek (Scott Creek)	X	X		X	X	X	X	X	X		X	X		X		X			X			
Mill Creek Res.	X					X	X	X	X	X	X	X				X	X		X			
Molino Creek	X	X			X	X	X	X	X						X	X			X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
San Vicente Creek	X	X	X	X	X	X	X	X	X		X	X		X	X	X			X			
Mill Creek (Bonnie Doon)	X				X	X	X	X	X		X	X							X			
Liddell Creek	X	X			X	X	X	X	X		X	X		X	X	X			X			
Liddell Creek, east branch	X	X		X	X	X	X	X	X		X	X							X			
Liddell Creek, west branch	X				X	X	X	X	X		X	X							X			
Laguna Creek Estuary					X	X	X	X	X		X	X		X	X				X			X
Laguna Creek	X	X		X	X	X	X	X	X		X	X		X		X			X			
Reggiardo Creek	X				X	X	X	X	X					X					X			
Majors Creek	X	X		X	X	X	X	X	X		X	X		X	X	X			X			
Baldwin Creek Estuary						X	X	X	X	X	X	X	X	X	X				X			X
Baldwin Creek	X	X			X	X	X	X	X		X	X	X	X		X			X			
Wilder Creek Estuary						X	X	X	X	X	X	X	X	X	X				X			X
Wilder Creek	X	X			X	X	X	X	X	X	X	X	X			X			X			
Cave Gulch	X				X	X	X	X	X	X									X			
Younger's Lagoon					X	X	X	X	X	X		X	X						X			X
Antonellis Pond					X	X	X	X		X	X	X		X					X			
Moore Creek	X	X			X	X	X	X	X	X		X	X			X			X			
Neary's Lagoon					X	X	X	X		X		X		X					X			
San Lorenzo River Estuary						X	X	X	X		X	X	X	X	X				X			
San Lorenzo River	X	X		X	X	X	X	X	X		X	X	X	X		X			X			
Branciforte Creek	X	X			X	X	X	X	X		X	X							X			
Blackburn Gulch	X				X	X	X	X	X		X	X							X			
Tie Gulch	X				X	X	X	X	X		X	X							X			
Granite Creek	X			X	X	X	X	X	X		X	X							X			
Carbonera Creek	X	X		X	X	X	X	X	X		X	X							X			
Zayante Creek	X	X		X	X	X	X	X	X		X	X							X			
Bean Creek	X	X		X	X	X	X	X	X		X	X							X			
Mackenzie Creek	X				X	X	X	X	X		X	X							X			
Ruins Creek	X				X	X	X	X	X		X	X							X			
Lockhart Gulch Creek	X				X	X	X	X	X		X	X							X			
Mountain Charlie Gulch	X				X	X	X	X	X		X	X							X			
Lompico Creek	X	X			X	X	X	X	X		X	X							X			
Mill Creek (SLR)	X				X	X	X	X	X										X			
Newell Creek	X	X		X	X	X	X	X	X		X	X				X			X			
Loch Lomond Res.	X	X		X	X	X	X	X	X	X	X	X		X		X	X		X			X
Love Creek	X				X	X	X	X	X		X	X							X			
Fritch Creek	X				X	X	X	X	X		X	X							X			
Smith Creek	X				X	X	X	X	X										X			
Spring Creek Gulch	X				X	X	X	X	X										X			
Bear Creek	X	X			X	X	X	X	X		X	X							X			
Connelly Gulch	X				X	X	X	X	X		X	X							X			
Shear Creek	X				X	X	X	X	X		X	X							X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Deer Creek	X				X	X	X	X	X		X	X							X			
Hopkins Gulch	X				X	X	X	X	X		X	X							X			
Two Bar Creek	X				X	X	X	X	X		X	X							X			
Kings Creek	X				X	X	X	X	X		X	X	X						X			
Logan Creek	X				X	X	X	X	X		X	X							X			
Sleeper Gulch	X				X	X	X	X	X				X						X			
McDonald Gulch	X				X	X	X	X	X		X	X	X						X			
Spring Creek	X				X	X	X	X	X		X	X							X			
Boulder Creek	X	X			X	X	X	X	X		X	X							X			
Bracken Brae Creek	X				X	X	X	X	X					X					X			
Hare Creek	X				X	X	X	X	X		X	X		X					X			
Jamison Creek	X				X	X	X	X	X		X	X							X			
Peavine Creek	X				X	X	X	X	X		X	X							X			
Silver Creek	X				X	X	X	X	X		X	X							X			
Foreman Creek	X				X	X	X	X	X		X	X							X			
Malosky Creek	X				X	X	X	X	X		X	X							X			
Clear Creek	X				X	X	X	X	X		X	X							X			
Alba Creek	X				X	X	X	X	X		X	X							X			
Marshall Creek	X				X	X	X	X	X		X	X							X			
Manson Creek	X				X	X	X	X	X		X	X							X			
Fall Creek	X	X		X	X	X	X	X	X		X	X	X						X			
South Fall Creek	X	X			X	X	X	X	X		X	X	X						X			
Bennett Creek	X	X		X	X	X	X	X	X		X	X	X						X			
Bull Creek	X				X	X	X	X	X			X							X			
Shingle Mill Creek	X				X	X	X	X	X		X	X							X			
Gold Gulch Creek	X				X	X	X	X	X		X	X							X			
Woods Lagoon						X	X	X			X	X			X				X			X
Arana Gulch	X				X	X	X	X	X		X	X		X		X			X			
Schwan Lake						X	X	X		X		X	X	X					X			X
Corcoran Lagoon					X	X	X	X		X		X		X	X				X			X
Rodeo Creek Gulch (Doyle Gulch)	X	X		X	X	X	X	X	X			X				X			X			
Moran Lake					X	X	X	X		X		X							X			
Soquel Lagoon						X	X	X	X		X	X		X	X				X			
Soquel Creek	X	X		X	X	X	X	X	X		X	X	X			X			X			
Bates Creek	X					X	X	X	X		X	X	X						X			
Grover Gulch	X				X	X	X	X	X		X	X							X			
Soquel Creek, east branch	X			X	X	X	X	X	X		X	X							X			
Hinckley Creek	X	X		X	X	X	X	X	X		X	X	X						X			
Amaya Creek	X				X	X	X	X	X		X	X							X			
Soquel Creek, west branch	X				X	X	X	X	X		X	X							X			
Hester Creek	X				X	X	X	X	X		X	X							X			
Laural Creek	X				X	X	X	X	X		X	X							X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Burns Creek	X				X	X	X	X	X		X	X							X			
Moores Gulch	X				X	X	X	X	X		X	X							X			
Miners Creek	X				X	X	X	X	X		X	X							X			
Aptos Creek	X	X		X	X	X	X	X	X		X	X	X		X	X			X			
Valencia Creek	X				X	X	X	X	X		X	X							X			
Trout Gulch	X				X	X	X	X	X										X			
Bridge Creek	X	X				X	X	X	X		X	X	X						X			
Valencia Lagoon						X	X	X		X		X		X					X			
PAJARO RIVER HYDROLOGIC UNIT																						
Corralitos Lagoon						X	X	X	X										X			
Palm Beach Pond	X					X	X	X		X				X					X			
Pinto Lake	X	X			X	X	X	X		X		X							X			
Kelley Lake	X	X			X	X	X	X		X		X							X			
Drew Lake	X	X			X	X	X	X		X		X							X			
Tynan Lake	X	X			X	X	X	X		X		X							X			
Warner Lake	X	X			X		X	X											X			
Pajaro River Estuary						X	X	X	X	X	X	X	X	X	X				X			X
Pajaro River	X	X		X	X	X	X	X	X	X	X	X				X			X			
San Benito River	X	X		X	X	X	X	X		X		X				X			X			
Bird Creek	X	X			X	X	X	X		X			X						X			
Pescadero Creek (S. Benito)	X	X			X	X	X	X	X	X	X	X							X			
Tres Pinos Creek	X	X		X	X	X	X	X		X		X							X			
Hernandez Reservoir	X	X			X	X	X	X		X		X				X	X		X			
Tequisquita Slough					X	X	X	X		X		X							X			
San Felipe Lake	X	X			X	X	X	X	X	X	X					X	X		X			
Pacheco Creek	X	X			X	X	X	X	X	X	X	X	X	X		X			X			
Pacheco Lake	X	X			X	X	X	X	X	X		X		X		X	X		X			
Llagas Creek (above Chesbro Res.)	X	X			X	X	X	X	X	X				X		X			X			
Chesbro Reservoir	X	X			X	X	X	X		X	X	X		X		X	X		X			
Llagas Creek (below Chesbro Res.)	X	X		X	X	X	X	X	X	X	X	X		X					X			
Alamias Creek	X	X			X	X	X	X	X	X	X	X							X			
Live Oak Creek	X	X			X	X	X	X	X	X	X								X			
Little Llagas Creek	X	X			X	X	X	X		X									X			
Carnadero Creek	X				X	X	X	X	X	X	X			X					X			
Uvas Creek, downstream	X	X		X	X	X	X	X	X	X	X	X		X					X			
Uvas Res.	X	X			X	X	X	X		X		X		X		X	X		X			
Little Arthur Creek	X	X			X	X	X	X	X	X	X	X							X			
Bodfish Creek	X	X			X	X	X	X	X	X	X	X		X					X			
Black Hawk Canyon Creek	X					X	X	X		X	X	X		X					X			
Uvas Creek, upstream	X				X	X	X	X	X		X	X		X		X			X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Little Uvas Creek	X	X			X	X	X	X		X									X			
Swanson Canyon Creek	X				X	X	X	X											X			
Alec Canyon Creek	X				X	X	X	X	X		X	X							X			
Croy Creek	X				X	X	X	X		X				X					X			
Eastman Canyon Creek	X	X			X	X	X	X		X									X			
Pescadero Creek	X	X			X	X	X	X	X		X	X	X						X			
Soda Lake							X	X		X				X					X			
Salsipuedes Creek	X	X			X	X	X	X	X		X	X							X			
Corralitos Creek	X	X		X	X	X	X	X	X	X	X	X							X			
Browns Creek	X	X		X	X	X	X	X	X	X	X	X							X			
Gamecock Creek	X				X	X	X	X	X		X	X							X			
Ramsey Gulch	X				X	X	X	X	X		X	X							X			
Redwood Creek	X					X	X	X	X		X	X							X			
Mormon Gulch	X				X	X	X	X	X										X			
Clipper Gulch	X				X	X	X	X	X										X			
Cookhouse Gulch	X				X	X	X	X	X										X			
Shingle Mill Gulch	X				X	X	X	X	X		X	X							X			
Rattlesnake Gulch	X				X	X	X	X	X										X			
Diablo Gulch Creek	X				X	X	X	X	X										X			
Eureka Gulch	X				X	X	X	X	X										X			
Rider Gulch Creek	X				X	X	X	X	X		X	X							X			
Watsonville Slough						X	X	X		X		X	X	X	X				X			
Struve Slough						X	X	X		X		X	X	X	X				X			
Hanson Slough						X	X	X		X		X	X	X	X				X			
Harkins Slough						X	X	X		X		X	X	X	X				X			
Gallighan Slough						X	X	X		X		X		X	X				X			
BOLSA NEUVA HYDROLOGIC UNIT																						
McClusky Slough					X	X	X	X		X		X		X					X			X
Elkhorn Slough						X	X	X	X	X	X	X	X	X	X		X		X	X		X
Los Carneros Creek	X					X	X	X	X		X	X		X		X			X			
Bennett Slough/Estuary						X	X	X	X	X		X	X	X	X				X			X
Parsons Slough						X	X	X	X			X	X	X	X				X			X
CARMEL RIVER HYDROLOGIC UNIT																						
Carmel River Estuary					X	X	X	X	X		X	X	X	X	X				X			X
Carmel River	X	X		X	X	X	X	X	X	X	X	X	X	X		X			X			
San Clemente Res.	X	X			X	X	X	X	X		X	X				X	X		X			
San Clemente Creek	X	X			X	X	X	X	X	X	X	X				X			X			
Pine Creek	X				X	X	X	X	X	X	X	X	X						X			
Los Padres Reservoir	X				X	X	X	X	X	X	X	X				X	X		X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Cachagua Creek	X	X	X	X	X	X	X	X	X	X	X	X				X			X			
Finch Creek	X				X	X	X	X	X	X	X	X	X	X					X			
Tularcitos Creek	X	X			X	X	X	X	X	X	X	X							X			
Rana Creek	X				X	X	X	X	X	X	X	X							X			
Chupines Creek	X				X	X	X	X	X	X	X	X							X			
Black Rock Creek	X					X	X	X	X		X	X		X		X			X			
White Rock Lake	X					X	X	X	X	X	X	X					X		X			
SANTA LUCIA HYDROLOGIC UNIT																						
San Jose Creek Estuary						X	X	X	X		X	X	X	X	X				X			X
San Jose Creek	X	X			X	X	X	X	X	X	X	X	X			X			X			
Garrapata Creek	X					X	X	X	X		X	X		X	X	X			X	X		
Palo Colorado Canyon	X	X			X	X	X	X	X	X		X			X	X			X			
Rocky Creek	X					X	X	X	X	X	X	X			X	X			X			
Bixby Creek	X					X	X	X	X		X	X		X	X	X			X			
Mill Creek	X					X	X	X	X		X	X							X			
Little Sur River Estuary						X	X	X	X		X	X	X	X	X				X			X
Little Sur River	X	X			X	X	X	X	X		X	X	X	X		X			X			
Big Sur River Estuary						X	X	X	X	X	X	X	X	X	X				X			X
Big Sur River	X	X			X	X	X	X	X	X	X	X	X	X		X			X			
Big Creek	X					X	X	X	X	X	X	X	X	X	X	X			X			
Devils Canyon Creek, south fork	X					X	X	X	X		X	X	X						X			
Devils Canyon Creek, middle fork	X					X	X	X	X		X	X	X						X			
Devils Canyon Creek, north fork	X					X	X	X	X		X	X	X						X			
Big Creek, north fork	X					X	X	X	X				X						X			
Limekiln Creek	X	X			X	X	X	X	X		X	X	X	X	X	X			X			
Mill Creek (Cape San Martin)	X					X	X	X	X	X	X	X			X	X			X			
Willow Creek	X				X	X	X	X	X		X	X		X	X	X			X			
Salmon Creek	X					X	X	X	X		X	X		X	X	X			X			
SALINAS HYDROLOGIC UNIT																						
Moro Cojo Slough					X	X	X	X	X	X		X	X	X	X				X			X
Old Salinas River Estuary						X	X	X	X	X	X	X	X	X	X				X			X
Tembldero Slough						X	X	X		X		X		X	X				X			X
Espinosa Lake						X	X	X		X									X			
Espinosa Slough						X	X	X		X									X			
Salinas Reclamation Canal						X	X	X		X									X			
Gabilan Creek	X	X			X	X	X	X		X		X							X			
Alisal Creek	X	X			X	X	X	X	X	X		X							X			
Blanco Drain						X	X	X		X									X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Salinas River Refuge Lagoon (South)						X	X	X	X	X	X		X	X					X			X
Marina Pond #1					X	X	X	X	X			X	X	X					X			
Marina Pond #2					X	X	X	X	X				X	X					X			
Marina Pond #3					X	X	X	X	X				X	X					X			
Marina Pond #4/5					X	X	X	X	X				X	X					X			
Marina Pond #6					X	X	X	X	X				X	X					X			
Marina Pond #7					X	X	X	X	X			X	X	X					X			
Laguna Grande/Roberts Lake	X					X	X	X	X	X									X			
Del Monte Lake	X					X	X	X		X									X			
⊟ Estero Lake	X				X	X	X	X	X	X		X							X			
Salinas River Lagoon (North)						X	X	X	X	X	X	X	X	X	X				X			X
Salinas River, dnstr of Spreckels Gage	X	X					X	X	X	X	X					X			X			
Salinas River, Spreckels Gage-Chualar	X	X	X	X	X	X	X	X	X	X	X								X			
Salinas Riv, Chualar-Nacimiento Riv	X	X	X	X	X	X	X	X	X	X	X	X		X					X			
Arroyo Seco River	X	X		X	X	X	X	X	X	X	X	X		X					X			
Abbott Lakes (The Lakes)	X				X	X	X	X	X	X		X					X		X			
Piney Creek	X					X	X	X	X		X	X							X			
Paloma Creek	X	X			X	X	X	X	X	X									X			
Tassajara Creek	X	X			X	X	X	X	X	X	X	X	X	X					X			
Santa Lucia Creek	X	X			X	X	X	X	X	X	X	X	X						X			
Vaqueros Creek	X	X				X	X	X	X		X	X							X			
Reliz Creek	X	X			X	X	X	X	X		X	X							X			
Hames Creek	X	X			X	X	X	X		X									X			
San Antonio Riv., dwnstr frm Res.	X	X		X	X	X	X	X		X	X	X		X					X			
San Antonio Reservoir	X	X			X	X	X	X	X	X		X		X		X	X	X	X			
San Antonio Riv, upstm Frm Res.	X	X		X	X	X	X	X	X	X	X	X		X		X			X			
Pancho Rico Creek	X	X			X	X	X	X		X		X							X			
San Lorenzo Creek	X	X			X	X	X	X		X		X							X			
Chalone Creek	X	X			X	X	X	X		X		X							X			
Salinas R.,Nacimiento R.-S. Margarita Res.	X	X	X		X	X	X	X	X	X	X	X		X					X			
Nacimiento River, upstream of Res.	X	X			X	X	X	X	X	X		X		X		X			X			
Salmon Creek	X					X	X	X	X		X	X		X					X			
Nacimiento Reservoir	X	X			X	X	X	X	X	X		X		X		X	X		X			
Nacimiento River, dwnstr Res.	X	X		X	X	X	X	X	X	X	X	X		X					X			
Las Tablas Creek	X	X			X	X	X	X	X	X		X		X					X			
Las Tablas Creek, north fork	X	X			X	X	X	X	X			X		X					X			
Las Tablas Creek, south fork	X	X			X	X	X	X	X			X		X					X			
Franklin Creek	X	X			X	X	X	X											X			
San Marcos Creek	X	X			X	X	X	X		X									X			
Paso Robles Creek	X	X			X	X	X	X	X		X	X		X					X			
Jack Creek	X	X			X	X	X	X	X		X	X		X					X			
Santa Rita Creek	X	X		X	X	X	X	X	X	X	X	X		X					X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Atascadero Creek	X	X			X	X	X	X	X			X		X					X			
Santa Margarita Reservoir (Lake)	X	X		X	X	X	X	X	X	X		X		X		X	X	X	X			
Salinas R., Reservoir-Headwaters	X	X			X	X	X	X	X		X	X				X			X			
Huerhuero Creek	X	X			X	X	X	X		X				X					X			
Vineyard Canyon Creek	X	X			X	X	X	X		X									X			
Big Sandy Creek	X	X			X	X	X	X		X			X	X					X			
Atascadero Lake	X				X	X	X	X	X	X		X					X		X			
ESTERO BAY HYDROLOGIC UNIT																						
San Carpoforo Creek Estuary						X	X	X	X		X	X	X	X	X				X			X
San Carpoforo Creek	X	X		X	X	X	X	X	X	X	X	X		X		X			X			
Estrada Creek	X	X			X	X	X	X	X	X									X			
Chris Flood Creek	X	X			X	X	X	X	X	X									X			
Wagner Creek	X	X			X	X	X	X	X	X									X			
Dutra Creek	X	X			X	X	X	X	X	X									X			
Arroyo de los Chinos	X	X			X	X	X	X	X	X				X	X	X			X			
Arroyo de la Cruz Estuary						X	X	X	X		X	X	X	X	X				X			X
Arroyo de la Cruz Creek	X	X		X	X	X	X	X	X	X	X	X		X		X			X			
Burnett Creek	X	X			X	X	X	X	X	X	X	X		X					X			
Arroyo del Oso	X	X			X	X	X	X	X					X	X	X			X			
Arroyo del Corral	X	X			X	X	X	X	X	X	X	X		X	X	X			X			
Oak Knoll Creek	X	X			X	X	X	X	X	X				X	X	X			X			
Arroyo Laguna						X	X	X	X			X		X	X				X			X
Little Pico Creek Estuary						X	X	X	X		X	X	X	X	X				X			X
Little Pico Creek	X	X			X	X	X	X	X		X	X		X		X			X			
Pico Creek Estuary					X	X	X	X	X	X	X	X	X	X	X				X			X
Pico Creek	X	X			X	X	X	X	X	X	X	X	X	X		X			X			
Pico Creek, south fork	X	X			X	X	X	X	X		X	X		X					X			
Pico Creek, north fork	X	X			X	X	X	X	X		X	X		X					X			
San Simeon Creek Estuary					X	X	X	X	X		X	X	X	X	X				X			X
San Simeon Creek	X	X		X	X	X	X	X	X	X	X	X	X	X		X			X			
Steiner Creek	X	X			X	X	X	X	X	X	X	X		X					X			
Santa Rosa Creek Estuary					X	X	X	X	X	X	X	X	X	X	X				X			X
Santa Rosa Creek	X	X		X	X	X	X	X	X	X	X	X		X		X			X			
Perry Creek	X	X			X	X	X	X	X					X					X			
Green Valley Creek	X	X			X	X	X	X	X	X				X					X			
Villa Creek	X	X			X	X	X	X	X		X	X		X	X	X			X			
Cayucos Creek	X	X			X	X	X	X	X	X	X	X	X	X	X	X			X			
Old Creek, downstream	X	X			X	X	X	X		X				X	X	X			X			
Whale Rock Reservoir	X	X	X	X	X	X	X	X	X	X		X		X		X	X		X			
Old Creek, upstream	X	X	X	X	X	X	X	X	X	X		X		X		X			X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Toro Creek	X	X			X	X	X	X	X	X	X	X		X	X	X			X			
Morro Creek	X	X			X	X	X	X	X	X	X	X		X	X	X			X			
Little Morro Creek	X	X			X	X	X	X	X		X	X		X					X			
Morro Bay Estuary				X		X	X	X	X		X	X	X	X	X				X	X		X
Chorro Creek	X	X			X	X	X	X	X	X	X	X	X	X		X			X			
Dairy Creek	X	X			X	X	X	X	X		X	X		X					X			
San Luisito Creek	X	X			X	X	X	X	X		X	X		X					X			
San Bernardo Creek	X	X			X	X	X	X	X		X	X		X					X			
Los Osos Creek	X	X			X	X	X	X	X	X	X	X		X		X			X			
Warden Lake Wetland		X			X	X	X	X		X		X		X					X			
Islay Creek	X	X			X	X	X	X	X		X	X	X	X	X	X			X			
Coon Creek	X	X			X	X	X	X	X		X	X	X	X	X	X			X			
Diablo Canyon Creek	X	X		X	X	X	X	X	X			X		X	X	X			X			
San Luis Obispo Creek Estuary (a)					X	X	X	X	X	X	X	X	X	X	X				X	X		X
S.L.O.Crk. above W. Marsh St.	X	X			X	X	X	X	X	X	X	X		X					X			
S.L.O.Crk. below W. Marsh St.	X	X			X	X	X	X	X	X	X	X				X			X			
Froom Creek	X					X	X	X						X					X			
Davenport Creek	X	X			X	X	X	X	X					X					X			
San Luis Obispo Creek, east fork	X	X			X	X	X	X	X		X	X		X					X			
Stenner Creek	X	X			X	X	X	X	X		X	X		X					X			
Brizziolari Creek	X	X			X	X	X	X	X		X	X		X					X			
Prefumo Creek	X	X			X	X	X	X	X		X	X		X		X			X			
Laguna Lake	X	X			X	X	X	X		X	X	X		X			X		X			
Pismo Creek Estuary					X	X	X	X	X		X	X	X	X	X				X			X
Pismo Creek	X	X		X	X	X	X	X	X	X	X	X	X	X		X			X			
Arroyo Grande Creek Estuary					X	X	X	X	X		X	X	X	X	X				X			X
Arroyo Grande Creek, downstream	X	X		X	X	X	X	X	X	X	X			X		X			X			
Oceano Lagoon						X	X	X		X		X	X	X					X			
Meadow Creek	X	X			X	X	X	X	X				X	X					X			
Pismo Marsh (Lake)					X	X	X	X		X			X	X					X			
Los Berros Creek	X	X			X	X	X	X	X		X			X					X			
Lopez Reservoir	X	X	X	X	X	X	X	X	X	X		X		X		X	X		X			
Arroyo Grande Creek, upstream	X	X	X	X	X	X	X	X	X	X	X	X		X					X			
Big Pocket Lake (Dunes Lakes)					X		X	X						X					X			
Willow Lake " "					X	X	X	X		X		X		X					X			
Pipeline Lake " "					X	X	X	X		X		X		X					X			
Celery Lake " "					X	X	X	X		X		X		X					X			
Hospital Lake " "					X	X	X	X		X		X		X					X			
Big Twin Lake " "					X	X	X	X		X		X		X					X			
Small Twin Lake " "						X	X	X		X		X		X					X			
Bolsa Chico Lake " "					X	X	X	X		X		X		X					X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
White Lake " "					X	X	X	X		X		X		X					X			
Mud Lake " "					X	X	X	X		X		X		X					X			
Black Lake " "					X	X	X	X		X		X		X					X			
Dune Lakes Marsh Area " "					X	X	X	X		X		X		X					X			
CARRIZO PLAIN HYDROLOGIC UNIT																						
San Diego Creek	X	X			X	X	X	X		X			X	X		X			X			
Soda Lake				X			X	X		X			X	X					X			
SANTA MARIA HYDROLOGIC UNIT																						
Oso Flaco Lake					X	X	X	X		X		X	X	X			X		X			
Oso Flaco Creek	X	X			X	X	X	X		X			X	X		X			X			
Santa Maria River Estuary					X	X	X	X		X	X	X	X	X	X				X			X
Santa Maria River	X	X		X	X	X	X	X	X	X	X			X		X			X			
Corralitos Canyon Creek	X	X				X	X	X											X			
Sisquoc River, downstream	X	X		X	X	X	X	X	X	X	X	X							X			
Sisquoc River, upstream	X				X	X	X	X	X		X	X	X	X					X			
Cuyama River, downstream	X	X			X	X	X	X		X				X					X			
Twitchell Reservoir	X	X			X		X	X		X				X		X			X			
Cuyama River, upstream	X	X	X	X	X	X	X	X	X	X		X		X		X			X			
Alamo Creek	X	X			X	X	X	X	X	X		X		X					X			
Huasna River	X	X			X	X	X	X		X				X					X			
Orcutt Creek	X	X			X	X	X	X	X					X	X	X			X			
SAN ANTONIO HYDROLOGIC UNIT																						
Shuman Canyon Creek	X	X				X	X	X		X		X			X	X			X			
Casmalia Canyon Creek	X	X				X	X	X		X		X							X			
San Antonio Creek Estuary					X	X	X	X	X	X	X	X	X	X	X				X			X
San Antonio Creek	X	X			X	X	X	X	X	X	X	X		X		X			X			
Barka Slough					X	X	X	X		X		X		X	X				X			X
SANTA YNEZ HYDROLOGIC UNIT																						
Santa Ynez River Estuary						X	X	X		X	X	X	X	X	X				X			X
Santa Ynez River, downstream	X	X	X	X	X	X	X	X	X	X	X	X		X		X			X			
Graves Wetland						X	X	X		X		X							X			
Lompoc Canyon	X	X		X	X	X	X	X		X									X			
La Salle Canyon Creek	X	X			X	X	X	X		X									X			
Sloans Canyon Creek	X				X	X	X	X		X									X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
San Miguelito Creek	X	X			X	X	X	X	X	X		X							X			
Salsipuedes Creek	X	X		X	X	X	X	X	X	X	X	X							X			
El Jaro Creek	X	X		X	X	X	X	X	X	X	X	X							X			
El Callejon Creek	X				X	X	X	X		X									X			
Llanito Creek	X				X	X	X	X		X									X			
Yridisis Creek	X	X			X	X	X	X		X		X							X			
Canada de la Vina	X	X			X	X	X	X		X									X			
Nojoqui Creek	X	X			X	X	X	X	X	X		X							X			
Alamo Pintado Creek	X	X		X	X	X	X	X		X									X			
Zaca Creek	X	X			X	X	X	X	X	X				X					X			
Zaca Lake	X					X	X	X	X	X		X		X					X			
Santa Rosa Creek	X	X			X	X	X	X	X	X	X	X							X			
Santa Rita Creek	X	X		X	X	X	X	X		X									X			
Davis Creek	X				X	X	X	X		X									X			
Santa Lucia Canyon Creek	X	X			X	X	X	X		X									X			
Oak Canyon Creek	X	X		X	X	X	X	X		X			X						X			
Hilton Creek	X	X			X	X	X	X	X		X	X							X			
Cachuma Reservoir	X	X	X		X	X	X	X	X	X		X		X		X	X		X			
Santa Ynez River, upstream	X	X	X	X	X	X	X	X	X	X	X	X		X		X			X			
Gibralter Reservoir	X	X	X	X	X	X	X	X	X	X		X		X		X	X		X			
Jameson Reservoir	X	X	X		X	X	X	X	X	X		X		X		X	X		X			
Agua Caliente Canyon	X	X		X	X	X	X	X	X	X		X		X					X			
Mono Creek	X	X		X	X	X	X	X	X	X	X	X		X					X			
Indian Creek	X	X		X	X	X	X	X	X	X	X	X	X	X					X			
Santa Cruz Creek	X	X		X	X	X	X	X	X	X	X	X		X					X			
Cachuma Creek	X				X	X	X	X	X	X	X	X		X					X			
SOUTH COAST HYDROLOGIC UNIT																						
Canada Honda Creek Estuary						X	X	X	X	X	X	X	X	X	X				X			X
Canada Honda Creek	X	X			X	X	X	X	X	X	X	X		X		X			X			
Canada Agua Viva	X				X	X	X	X		X					X	X			X			
Water Canyon Creek	X				X	X	X	X		X			X		X	X			X			
Canada del Jolloru	X					X	X	X		X					X	X			X			
Jalama Creek Estuary						X	X	X		X	X	X	X	X	X				X			X
Jalama Creek	X	X			X	X	X	X		X		X				X			X			
Escondido Creek	X				X	X	X	X	X	X	X	X		X					X			
Gasper Creek	X				X	X	X	X		X									X			
Espada Creek	X				X	X	X	X		X									X			
Wood Canyon Creek	X				X	X	X	X		X					X	X			X			
Canada del Cojo	X				X	X	X	X		X					X	X			X			
Barranca Honda	X	X			X	X	X	X		X				X	X	X			X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Arroyo Bulito	X	X			X	X	X	X		X					X	X			X			
Canada de Santa Anita	X	X			X	X	X	X		X					X	X			X			
Canada del Sacate	X	X			X	X	X	X		X					X	X			X			
Canada Alegria	X				X	X	X	X		X					X	X			X			
Canada del Agua Caliente	X	X			X	X	X	X	X	X					X	X			X			
Canada de la Gaviota	X	X			X	X	X	X	X	X	X	X	X	X	X	X			X			
Canada San Onofre	X					X	X	X	X	X	X	X		X	X	X			X			
Canada del Molino	X					X	X	X		X				X	X	X			X			
Arroyo Hondo	X					X	X	X	X	X	X	X		X	X	X			X			
Arroyo Quenado	X	X				X	X	X	X		X	X		X	X	X			X			
Tajigas Creek	X	X			X	X	X	X	X	X	X	X		X	X	X			X			
Canada del Refugio	X	X			X	X	X	X	X	X	X	X	X	X	X	X			X			
Canada del Capitan	X	X			X	X	X	X	X	X	X	X	X	X	X	X			X			
Dos Pueblos Canyon Creek	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X			X			
Tecolote Creek	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X			X			
Devereaux Ranch Lagoon						X	X	X		X	X	X	X	X	X				X			X
Devereaux Creek	X				X	X	X	X		X						X			X			
Goleta Point Marsh						X	X	X		X		X	X	X					X			
Goleta Slough/Estuary						X	X	X		X	X	X	X	X	X				X			X
Carneros Creek	X	X			X	X	X	X	X	X						X			X			
Tecolotito Creek	X				X	X	X	X	X	X	X					X			X			
Glen Anne Creek	X	X	X	X	X	X	X	X	X	X	X	X		X		X			X			
Los Caneros Wetland					X	X	X	X		X		X		X					X			
Los Caneros	X	X			X	X	X	X		X		X		X		X			X			
Atascadero Creek (SB)	X	X			X	X	X	X	X	X	X	X		X		X			X			
Maria Ygnacio Creek	X	X			X	X	X	X	X		X	X							X			
San Antonio Creek (S Barbara County)	X	X			X	X	X	X	X	X	X	X		X					X			
San Jose Creek (S Barbara County)	X	X			X	X	X	X	X	X	X	X		X		X			X			
Las Vegas Creek	X				X	X	X	X	X	X									X			
San Pedro Creek	X	X			X	X	X	X	X	X	X					X			X			
Las Palmas Creek	X				X	X	X	X		X									X			
Arroyo Burro Estuary						X	X	X		X		X			X				X			
Arroyo Burro Creek	X				X	X	X	X		X		X	X	X		X			X			
Mission Creek	X				X	X	X	X	X	X	X	X		X	X	X			X			
Rattlesnake Canyon	X				X	X	X	X	X	X	X	X							X			
Waste Slough					X	X	X	X		X		X							X			
Sycamore Creek	X	X			X	X	X	X	X	X	X	X		X	X	X			X			
Andree Clark Bird Refuge						X	X	X		X			X	X					X			X
San Ysidro Creek	X				X	X	X	X		X					X	X			X			
Romero Creek	X				X	X	X	X		X					X	X			X			
Toro Canyon Creek	X				X	X	X	X		X					X	X			X			
Arroyo Paredon	X	X			X	X	X	X		X	X	X		X	X	X			X			

Table 2-1. Identified Uses of Inland Surface Waters

Waterbody Names	MUN	AGR	PRO	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	POW	COMM	AQUA	SAL	SHELL
Carpinteria Marsh (El Estero Marsh)						X	X	X		X	X	X	X	X	X				X			
Santa Monica Creek	X	X			X	X	X	X	X	X		X	X			X			X			
Franklin Creek	X	X			X	X	X	X	X	X	X	X		X		X			X			
Carpinteria Creek	X	X			X	X	X	X	X	X	X	X	X	X	X	X			X			
Gobernador Creek	X				X	X	X	X	X	X		X							X			
Steer Creek	X					X	X	X	X	X	X	X							X			
Rincon Creek	X	X			X	X	X	X	X	X	X	X		X	X	X			X			
SANTA BARBARA CHANNEL HYDROLOGIC UNIT																						
SANTA ROSA ISLAND																						
Canada Lobos Creek	X	X				X	X	X		X			X	X					X			
Old Ranch Canyon Creek	X	X				X	X	X		X			X	X		X			X			
Arlington Canyon Creek	X	X				X	X	X		X			X	X					X			
Water Canyon Creek	X	X				X	X	X		X			X	X					X			
Cow Canyon Creek	X	X				X	X	X		X			X	X					X			
Clapp Springs	X	X				X	X	X		X			X	X					X			
Old Ranch Canyon Creek Estuaries		X				X	X	X		X			X	X	X				X			
Old Ranch House Canyon Creek	X	X				X	X	X		X			X	X		X			X			
Cherry Canyon Creek	X	X				X	X	X		X			X	X					X			
SANTA CRUZ ISLAND																						
Willow Canyon Creek	X					X	X	X		X			X	X					X			
Coches Prieto Canyon Creek	X					X	X	X		X			X	X					X			
Almos Anchorage Canyon Creek	X					X	X	X		X			X	X					X			
Canada del Puerta (Prisoner Harbor)	X					X	X	X		X			X	X					X			
Canada Larga Creek	X					X	X	X		X			X	X					X			
Upper Pozo Canyon Creek	X					X	X	X		X			X	X					X			
Sauces Canyon Creek	X					X	X	X		X			X	X					X			
Twin Harbors Canyon Ck, (E. Fork)	X					X	X	X		X			X	X					X			
Lady's Harbor Canyon Creek	X					X	X	X		X			X	X					X			
ESTRELLA RIVER HYDROLOGIC UNIT																						
Estrella River	X	X			X	X	X	X		X		X							X			
San Juan Creek	X	X			X	X	X	X		X				X					X			
Chalome Creek	X	X			X	X	X	X		X				X					X			
Little Chalome Creek	X	X			X	X	X	X		X				X					X			

Figure 2-1. Central Coast Hydrologic Planning Area

FIGURE 2-1. CENTRAL COAST HYDROLOGIC PLANNING AREA

Table 2-2. Existing and Anticipated Uses of Coastal Waters[a]

Coastal Water	REC-1	REC-2	IND	NAV	MAR	SHELL	COMM	RARE	ASBS	WILD
Pescadero Pt. to Pt. Ano Nuevo		E	E	E	E	E	E	E	E	E
Pt. Ano Nuevo to Soquel Pt.	E	E	E	E	E	E	E	E		
Pt. Ano Nuevo and Island	E	E	E	E	E	E				
Santa Cruz Harbor	E	E	E	E	E		E			
San Lorenzo Esturary	E	E		E	E	E	E	E		
Soquel Pt. to Salinas River	E	E	E	E	E	E	E	E		E
Elkhorn Slough[b]	E	E	E	E	E	E		E		
Moss Landing Harbor	E	E	E	E	E	E[c]	E	E		E
Salinas River to Pt. Pinos	E	E	E	E	E	E	E	E		
Monterey Harbor	A	E	E	E	E	E	A	E		
Pacific Grove Marine Gardens	E	E	E		E	E	E	E		
Hopkins Marine Life Refuge	E	E	E		E	E	E	E		
Pt. Pinos to Pt. Piedras Blancas	E	E		E	E		E	E		E
Carmel Bay	E	E	E		E	E	E	E		
Pt. Lobos State Reserve	E	E	E	E	E	E				
Pt. Sur	E	E	E	E	E	E				
Pfeiffer-Burns State Park	E	E	E	E	E	E				
Ocean Area Surrounding Salmon Creek	E	E	E		E	E				
Pt. Piedras Blancas to Pt. Estero		E	E		E	E	E	E	E	E
Estero Bay	E	E	E	E	E	E	E	E		E
Morro Bay	E	E	E	E	E	E	E	E		E
Pt. Buchon to Pt. San Luis	E	E	E	E	E	E	E	E		
Pt. San Luis to Pt. Sal	E	E	E	E	E	E	E	E		E
Pt. Sal to Pt. Arguello	E	E		E	E	E	E	E		
Pt. Arguello to Coal Oil Pt.	E	E	E	E	E	E	E			
Coal Oil Pt. to Rincon Pt.	E	E	E	E	E	E	E	E		E
Goleta Slough	E	E	E	E		E		E		
Santa Barbara Harbor	E	E	E	E	E		E			
Beach Parks	E	E		E	E					
San Miguel Island	E	E		E	E	E	E	E	E	E
Santa Rosa Island	E	E		E	E	E	E		E	E
Santa Cruz Island	E	E		E	E	E	E	E	E	E
El Estero	E	E	E	E		E		E		

a This table lists selected coastal segments. It is not a complete inventory for the Central Coast Region. Unlisted water bodies have implied beneficial use designations for protection of both recreation and aquatic life.

b Elkhorn Slough has been designated an ecological reserve by the California Department of Fish and Game, and recognized as a National Estuary Sanctuary by the Federal Government.

c Clamming is an existing beneficial use in the North Harbor and on the south side of the entrance channel to Elkhorn Slough (north of the Pacific Gas and Electric Cooling Water Intake). Presently, no shellfishing use occurs south of the Pacific Gas and Electric Intake.

NOTES: E = Existing beneficial water use
A = Anticipated beneficial water use

Table 2-3. Central Coastal Ground Water Basins[a]

Name	County
Ano Nuevo Area (3-20)	San Mateo
Arroyo de la Cruz Valley (3-34)	San Luis Obispo
Arroyo Grande Valley-Nipoma Mesa Area (3-11)	San Luis Obispo
Big Spring Area (3-47)	San Luis Obispo
Bitter Water Valley (3-30)	San Benito
Careaga Sand Highlands (3-48)	Santa Barbara
Carmel Valley (3-7)	Monterey
Carpinteria Basin (3-18)	Santa Barbara
Carrizo Plain (3-19)	San Luis Obispo
Cayucos Valley (3-38)	San Luis Obispo
Cholame Valley (3-5)	Monterey, San Luis Obispo
Chorro Valley (3-42)	San Luis Obispo
Corral de Tierra Area (3-4.10)	Monterey
Cuyama Valley (3-13)	Kern, San Luis Obispo, Santa Barbara, Ventura
Dry Lake Valley (3-29)	Benito
Gilroy-Hollister Valley (3-3)	Benito, Santa Clara
Goleta Basin (3-16)	Santa Barbara
Hernandez Valley (3-31)	Benito
Huasna Valley (3-45)	San Luis Obispo
Langley Area (3-4.09)	Monterey
Lockwood Valley (3-6)	Monterey
Los Osos Valley (3-8)	San Luis Obispo
Montecito Area (3-49)	Santa Barbara
Morro Valley (3-41)	San Luis Obispo
Old Valley (3-39)	San Luis Obispo
Pajaro Valley (3-2)	Monterey, Santa Cruz
Paso Robles Basin (3-4.06)	Monterey, San Luis Obispo
Peach Tree Valley (3-32)	San Benito
Pismo Creek Valley (3-10)	San Luis Obispo
Pozo Valley (3-44)	San Luis Obispo
Quien Sabe Valley (3-24)	San Benito
Rafael Valley (3-46)	San Luis Obispo
Rinconada Valley (3-43)	San Luis Obispo
Salinas Valley (3-4)	Monterey
San Antonio Creek Valley (3-14)	Santa Barbara
San Benito River Valley (3-28)	San Benito
San Carpoforo Valley (3-33)	San Luis Obispo
San Luis Obispo Valley (3-9)	San Luis Obispo
San Simeon Valley (3-35)	San Luis Obispo
Santa Ana Valley (3-22)	San Benito
Santa Barbara Basin (3-17)	Santa Barbara
Santa Cruz Purisima Formation Highlands (3-21)	Santa Cruz
Santa Maria River Valley (3-12)	San Luis Obispo, Santa Barbara
Santa Rosa Valley (3-36)	San Luis Obispo
Santa Ynez River Valley (3-15)	Santa Barbara
Scotts Valley (3-27)	Santa Cruz
Seaside Area (3-4.08)	Monterey
Soquel Valley (3-1)	Santa Cruz
Toro Valley (3-40)	San Luis Obispo
Tres Pinos Creek Valley (3-25)	San Benito
Upper Santa Ana Valley (3-23)	San Benito
Villa Valley (3-37)	San Luis Obispo
West Santa Cruz Terrace (3-26)	Santa Cruz

a Basin number locations identified on Figure 2-2.

Figure 2-2. Central Coast Groundwater Basins

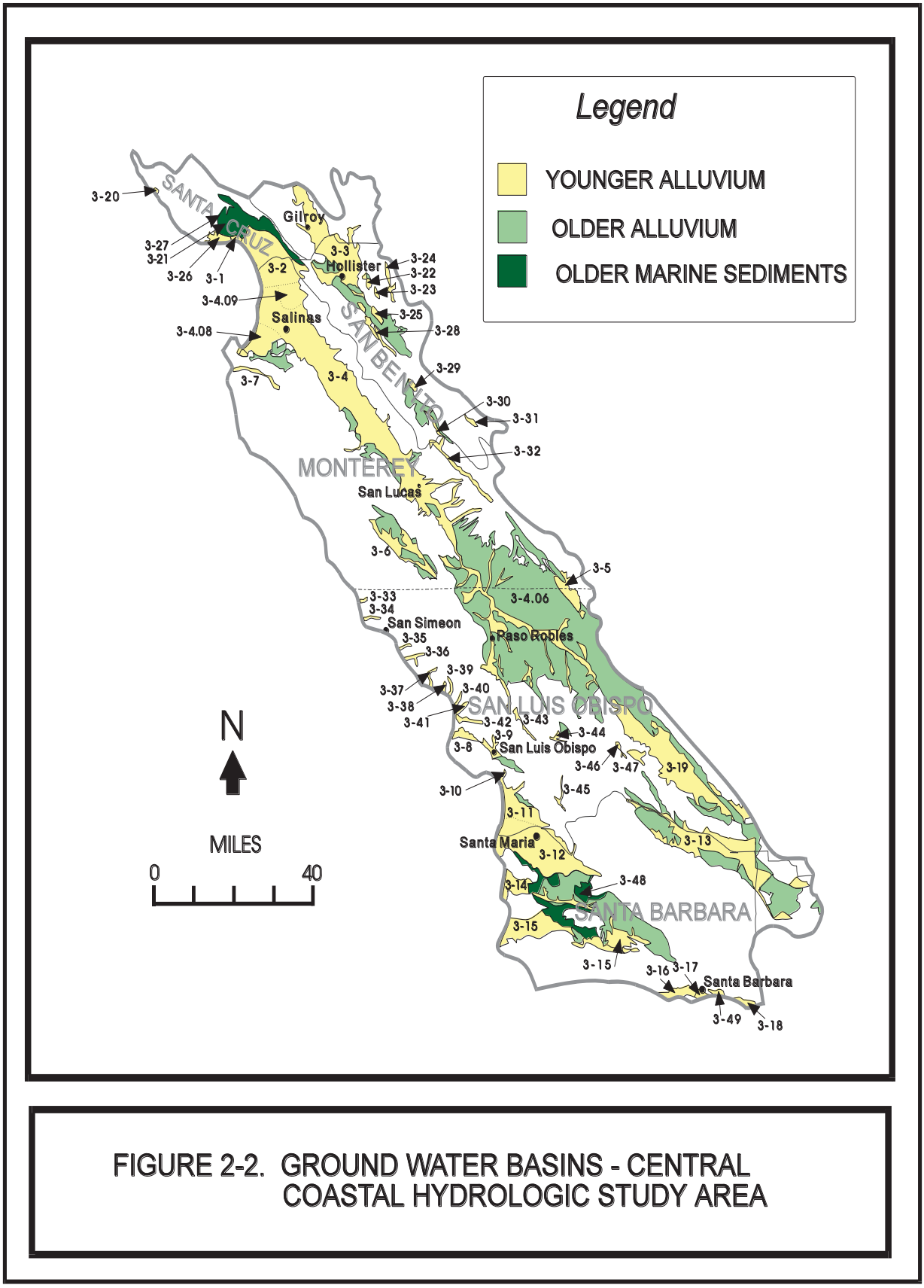

FIGURE 2-2. GROUND WATER BASINS - CENTRAL COASTAL HYDROLOGIC STUDY AREA

d. The water is in collection or treatment systems of municipal or industrial wastewaters, process waters, mining wastewaters, or storm water runoff; and
e. The water is in systems for conveying or holding agricultural drainage waters.

Agricultural Supply (AGR) - Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

Industrial Process Supply (PROC) - Uses of water for industrial activities that depend primarily on water quality (i.e., waters used for manufacturing, food processing, etc.).

Industrial Service Supply (IND) - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.

Ground Water Recharge (GWR) - Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers. Ground water recharge includes recharge of surface water underflow.

Freshwater Replenishment (FRSH) - Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity) which includes a water body that supplies water to a different type of water body, such as, streams that supply reservoirs and lakes, or estuaries; or reservoirs and lakes that supply streams. This includes only immediate upstream water bodies and not their tributaries.

Navigation (NAV) - Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels. This Board interprets NAV as, "Any stream, lake, arm of the sea, or other natural body of water that is actually navigable and that, by itself, or by its connections with other waters, for a period long enough to be of commercial value, is of sufficient capacity to float watercraft for the purposes of commerce, trade, transportation, and including pleasure; or any waters that have been declared navigable by the Congress of the United States" and/or the California State Lands Commission.

Hydropower Generation (POW) - Uses of water for hydropower generation.

Water Contact Recreation (REC-1) - Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-Contact Water Recreation (REC-2) - Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Commercial and Sport Fishing (COMM) - Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Aquaculture (AQUA) - Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Warm Fresh Water Habitat (WARM) - Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Fresh Water Habitat (COLD) - Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.

Inland Saline Water Habitat (SAL) - Uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates. Soda Lake is a saline habitat typical of desert lakes in inland sinks.

Estuarine Habitat (EST) - Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds). An estuary is generally described as a semi-enclosed body of water having a free connection with the open sea, at least part of the year and within which the seawater is diluted at least seasonally with fresh water drained from the land. Included are water bodies which would naturally fit the definition if not controlled by tidegates or other such devices.

Marine Habitat (MAR) - Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

Wildlife Habitat (WILD) - Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Preservation of Biological Habitats of Special Significance (BIOL) - Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.

Rare, Threatened, or Endangered Species (RARE) - Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

Migration of Aquatic Organisms (MIGR) - Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN) - Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Shellfish Harvesting (SHELL) - Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport purposes. This includes waters that have in the past, or may in the future, contain significant shellfisheries.

Areas of Special Biological Significance (ASBS) - are those areas designated by the State Water Resources Control Board as requiring protection of species or biological communities to the extent that alteration of natural water quality is undesirable.

The following areas have been designated Areas of Special Biological Significance in the Central Coastal Basin:

1. Ano Nuevo Point and Island, San Mateo County

2 Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge, Monterey County

3. Point Lobos Ecological Reserve, Monterey County

4. Carmel Bay, Monterey County

5 Julia Pfeiffer Burns Underwater Park, Monterey County

6. Ocean area surrounding the mouth of Salmon Creek, Monterey County

7. Channel Islands, Santa Barbara County - San Miguel, Santa Rosa, Santa Cruz

An ASBS designation implies the following requirements:

Discharge of elevated temperature wastes in a manner that would alter water quality conditions from those occurring naturally will be prohibited.

Discharge of discrete, point source sewage or industrial process wastes in a manner that would alter water quality conditions from those occurring naturally will be prohibited.

Discharge of waste from nonpoint sources, including but not limited to storm water runoff, silt, and urban runoff, will be controlled to the extent practicable. In control programs for waste from nonpoint sources, Regional Boards will give high priority to areas tributary to ASBS.

Further information concerning ASBS areas can be found by reviewing Regional Board Policies in Chapter Five.

CHAPTER 3. WATER QUALITY OBJECTIVES

Section 13241, Division 7 of the California Water Code specifies that each Regional Water Quality Control Board shall establish water quality objectives which, in the Regional Board's judgment, are necessary for the reasonable protection of beneficial uses and for the prevention of nuisance.

Section 303 of the 1972 Amendments to the federal Water Pollution Control Act requires the State to submit to the Administrator of the U.S. Environmental Protection Agency (U.S. EPA) for approval, all new or revised water quality standards which are established for surface and ocean waters. Under federal terminology, water quality standards consist of beneficial uses enumerated in Chapter Two and water quality objectives contained in this chapter.

Water quality objectives contained herein are designed to satisfy all State and federal requirements.

As new information becomes available, the Regional Board will review the appropriateness of objectives contained herein. These objectives are subject to public hearing at least once during each three-year period following adoption of this plan for the purpose of review and modification as appropriate.

I. CONSIDERATIONS IN SELECTING WATER QUALITY OBJECTIVES

The aforementioned 1972 Amendments to the federal Water Pollution Control Act declare that a national goal is elimination of discharge of pollutants into navigable waters.

A prerequisite to water quality control planning is the establishment of a base or reference point. The base in this instance was various general and specific water quality criteria previously found acceptable for particular beneficial uses or selected sources of waste. Current technical guidelines, available historical data, and enforcement feasibility were given full consideration in formulating water quality objectives.

A distinction is made here between the terms "water quality objectives" and "water quality standards". Water quality objectives have been adopted by the State and, when applicable, extended as federal water quality standards. Water quality standards, previously mentioned in this chapter's introduction, pertain to navigable waters and become legally enforceable criteria when accepted by the U.S. EPA Regional Administrator.

Point and nonpoint water pollution sources described herein have the same meaning as defined in the federal Water Pollution Control Act. Point sources are waste loads from identifiable sources such as municipal discharges, industrial discharges, vessels, controllable storm waters, fish hatchery discharges, confined animal operations, and agricultural drains. Nonpoint sources are waste loads resulting from land use practices where wastes are not collected and disposed of in any readily identifiable manner. Examples include: urban drainage, agricultural runoff, road construction activities, mining, grassland management, logging and other harvest activities, and natural sources such as effects of fire, flood, and landslide. The distinction between point sources and diffuse sources is not always clear but generally applies to the practicality of waste load control.

Water quality objectives for the Central Coastal Basin satisfy State and federal requirements to protect waters for the beneficial uses in Chapter Two and are consistent with all existing statewide plans and policies.

II. WATER QUALITY OBJECTIVES

The water quality objectives which follow supersede and replace those contained in the 1967 Water Quality Control Policies; the Interim Water Quality Control Plan for the Central Coastal Basin adopted by the Regional Board in 1971, including all existing revisions; and the Water Quality Control Plan Report for the Central Coastal Basin, adopted by the Regional Board in 1974.

Controllable water quality shall conform to the water quality objectives contained herein. When other conditions cause degradation of water quality beyond the levels or limits established as water quality objectives, controllable conditions shall not cause further degradation of water quality.

Controllable water quality conditions are those actions or circumstances resulting from man's activities that may influence the quality of the waters of the State and that may be reasonably controlled.

Water quality objectives are considered to be necessary to protect those present and probable future beneficial uses enumerated in Chapter Two of this plan and to protect existing high quality waters of the State. These objectives will be achieved primarily through the establishment of waste discharge requirements and through implementation of this water quality control plan.

In setting waste discharge requirements, the Regional Board will consider the potential impact on beneficial uses within the area of influence of the discharge, the existing quality of receiving waters, and the appropriate water quality objectives. The Regional Board will make a finding of beneficial uses to be protected and establish waste discharge requirements to protect those uses and to meet water quality objectives.

Several water quality objectives listed herein originate from the California Code of Regulations, Title 22. If Title 22 concentrations are amended, Basin Plan objectives are automatically amended to correspond with the new regulations.

II.A. ANTI-DEGRADATION POLICY

Wherever the existing quality of water is better than the quality of water established herein as objectives, such existing quality shall be maintained unless otherwise provided by the provisions of the State Water Resources Control Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California," including any revisions thereto. A copy of this policy is included in the Appendix.

II.A.1. OBJECTIVES FOR OCEAN WATERS

The provisions of the State Board's "Water Quality Control Plan for Ocean Waters of California" (Ocean Plan), "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California" (Thermal Plan), and any revisions thereto shall apply in their entirety to affected waters of the basin. The Ocean and Thermal Plans shall also apply in their entirety to Monterey Bay and Carmel Bay. Copies of these plans are included verbatim in the Appendix.

In addition to provisions of the Ocean Plan and Thermal Plan, the following objectives shall also apply to all ocean waters, including Monterey and Carmel Bays:

<u>Dissolved Oxygen</u>

The mean annual dissolved oxygen concentration shall not be less than 7.0 mg/l, nor shall the minimum dissolved oxygen concentration be reduced below 5.0 mg/l at any time.

<u>pH</u>

The pH value shall not be depressed below 7.0, nor raised above 8.5.

<u>Radioactivity</u>

Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life; or result in the accumulation of radionuclides in the food web to an extent which

presents a hazard to human, plant, animal, or aquatic life.

II.A.2. OBJECTIVES FOR ALL INLAND SURFACE WATERS, ENCLOSED BAYS, AND ESTUARIES

II.A.2.a. GENERAL OBJECTIVES

The following objectives apply to all inland surface waters, enclosed bays, and estuaries of the basin:

Color

Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses. Coloration attributable to materials of waste origin shall not be greater than 15 units or 10 percent above natural background color, whichever is greater.

Tastes and Odors

Waters shall not contain taste or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, that cause nuisance, or that adversely affect beneficial uses.

Floating Material

Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.

Suspended Material

Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

Settleable Material

Waters shall not contain settleable material in concentrations that result in deposition of material that causes nuisance or adversely affects beneficial uses.

Oil and Grease

Waters shall not contain oils, greases, waxes, or other similar materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.

Biostimulatory Substances

Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

Sediment

The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Turbidity

Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses.

Increase in turbidity attributable to controllable water quality factors shall not exceed the following limits:

1. Where natural turbidity is between 0 and 50 Jackson Turbidity Units (JTU), increases shall not exceed 20 percent.

2. Where natural turbidity is between 50 and 100 JTU, increases shall not exceed 10 JTU.

3. Where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent.

Allowable zones of dilution within which higher concentrations will be tolerated will be defined for each discharge in discharge permits.

pH

For waters not mentioned by a specific beneficial use, the pH value shall not be depressed below 7.0 or raised above 8.5.

Dissolved Oxygen

For waters not mentioned by a specific beneficial use, dissolved oxygen concentration shall not be reduced below 5.0 mg/l at any time. Median values should not fall below 85 percent saturation as a result of controllable water quality conditions.

Temperature

Temperature objectives for Enclosed Bays and Estuaries are as specified in the "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California" including any revisions thereto. A copy of this plan is included in the Appendix.

Natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses.

Toxicity

All waters shall be maintained free of toxic substances in concentrations which are toxic to, or which produce detrimental physiological responses in, human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, toxicity bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board.

Survival of aquatic life in surface waters subjected to a waste discharge or other controllable water quality conditions, shall not be less than that for the same water body in areas unaffected by the waste discharge or, when necessary, for other control water that is consistent with the requirements for "experimental water" as described in Standard Methods for the Examination of Water and Wastewater, latest edition. As a minimum, compliance with this objective shall be evaluated with a 96-hour bioassay.

In addition, effluent limits based upon acute bioassays of effluents will be prescribed where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances is encouraged.

The discharge of wastes shall not cause concentrations of unionized ammonia (NH_3) to exceed 0.025 mg/l (as N) in receiving waters.

Pesticides

No individual pesticide or combination of pesticides shall reach concentrations that adversely affect beneficial uses. There shall be no increase in pesticide concentrations found in bottom sediments or aquatic life.

For waters where existing concentrations are presently nondetectable or where beneficial uses would be impaired by concentrations in excess of nondetectable levels, total identifiable chlorinated hydrocarbon pesticides shall not be present at concentrations detectable within the accuracy of analytical methods prescribed in Standard Methods for the Examination of Water and Wastewater, latest edition, or other equivalent methods approved by the Executive Officer.

Chemical Constituents

Where wastewater effluents are returned to land for irrigation uses, regulatory controls shall be consistent with Title 22 of the California Code of Regulations and other relevant local controls.

Other Organics

Waters shall not contain organic substances in concentrations greater than the following:

Methylene Blue Activated Substances	0.2 mg/l
Phenols	0.1 mg/l
PCB's	0.3 μg/l
Phthalate Esters	0.002 μg/l

Radioactivity

Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life; or result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal, or aquatic life.

MUNICIPAL AND DOMESTIC SUPPLY (MUN)

pH

The pH value shall neither be depressed below 6.5 nor raised above 8.3.

Organic Chemicals

All inland surface waters, enclosed bays, and estuaries shall not contain concentrations of organic chemicals in excess of the limiting concentrations set forth in California Code of Regulations, Title 22, Chapter 15, Article 5.5, Section 64444.5, Table 5 and listed in Table 3-1.

Chemical Constituents

Waters shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Article 4, Chapter 15, Section 64435, Tables 2 and 3 as listed in Table 3-2.

Phenol

Waters shall not contain phenol concentrations in excess of 1.0 μg/l.

Radioactivity

Waters shall not contain concentrations of radionuclides in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 5, Sections 64441 and 64443, Table 4.

AGRICULTURAL SUPPLY (AGR)

pH

The pH value shall neither be depressed below 6.5 nor raised above 8.3.

Dissolved Oxygen

Dissolved oxygen concentration shall not be reduced below 2.0 mg/l at any time.

Chemical Constituents

Waters shall not contain concentrations of chemical constituents in amounts which adversely affect the agricultural beneficial use. Interpretation of adverse effect shall be as derived from the University of California Agricultural Extension Service guidelines provided in Table 3-3.

In addition, waters used for irrigation and livestock watering shall not exceed concentrations for those chemicals listed in Table 3-4. Salt concentrations for irrigation waters shall be controlled through implementation of the anti-degradation policy to the effect that mineral constituents of currently or potentially usable waters shall not be increased. It is emphasized that no controllable water quality factor shall degrade the quality of any ground water resource or adversely affect long-term soil productivity.

Where wastewater effluents are returned to land for irrigation uses, regulatory controls shall be consistent with Title 22 of the California Code of Regulations and with relevant controls for local irrigation sources.

WATER CONTACT RECREATION (REC-1)

pH

The pH value shall neither be depressed below 6.5 nor raised above 8.3.

Table 3-1. Organic Concentrations Not to be Exceeded in Domestic or Municipal Supply

Constituent		Maximum Contaminant Level (MCL), mg/l
(a)	Chlorinated Hydrocarbons	
	Endrin	0.0002
	Lindane	0.004
	Methoxychlor	0.1
	Toxaphene	0.005
(b)	Chlorophenoxys	
	2,4-D	0.1
	2,4,5-TP Silvex	0.01
(c)	Synthetics	
	Atrazine	0.003
	Bentazon	0.018
	Benzene	0.001
	Carbon Tetrachloride	0.0005
	Carbofuran	0.018
	Chlordane	0.0001
	1,2-Dibromo-3-chloropropane	0.0002
	1,4-Dichlorobenzene	0.005
	1,1-Dichloroethane	0.005
	1,2-Dichloroethane	0.0005
	cis-1,2-Dichloroethylene	0.006
	trans-1,2-Dichloroethylene	0.01
	1,1-Dichloroethylene	0.006
	1,2-Dichloropropane	0.005
	1,3-Dichloropropene	0.0005
	Di(2-ethylhexyl) phthalate	0.004
	Ethylbenzene	0.680
	Ethylene Dibromide	0.00002
	Glyphosate	0.7
	Heptachlor	0.00001
	Heptachlor epoxide	0.00001
	Molinate	0.02
	Monochlorobenzene	0.030
	Simazine	0.010
	1,1,2,2-Tetrachloroethane	0.001
	Tetrachloroethylene	0.005
	Thiobencarb	0.07
	1,1,1-Trichloroethane	0.200
	1,1,2-Trichloroethane	0.032
	Trichloroethylene	0.005
	Trichlorofluromethane	0.15
	1,1,2-Trichloro-1,2,2-Trifluoroethane	1.2
	Vinyl Chloride	0.0005
	*Xylenes	1.750

* MCL is for either a single isomer or the sum of the isomers.

Table 3-2. Inorganic and Fluoride Concentrations Not to be Exceeded in Domestic or Municipal Supply

Constituent	Limiting Concentration ,mg/l			
	Lower	Optimum	Upper	Maximum Contaminant Level
Temperature °F*	Fluoride			
53.7° and below	0.9	1.2	1.7	2.4
53.8° to 58.3°	0.8	1.1	1.5	2.2
58.4° to 63.8°	0.8	1.0	1.3	2.0
63.9° to 70.6°	0.7	0.9	1.2	1.8
70.7° to 79.2°	0.7	0.8	1.0	1.6
79.3° to 90.5°	0.6	0.7	0.8	1.4
Inorganic Chemicals				Maximum Contaminant Level
Aluminum				1
Arsenic				0.05
Barium				1
Cadmium				0.010
Chromium				0.05
Lead				0.05
Mercury				0.002
Nitrate (as NO3)				45
Selenium				0.01
Silver				0.05

*Annual Average of Maximum Daily Air Temperature, °F based on temperature data obtained for a minimum of five years.

Table 3-3. Guidelines for Interpretation of Quality of Water for Irrigation[a]

Problem and Related Constituent	No Problem	Water Quality Guidelines Increasing Problems	Severe
Salinity[b]			
EC of irrigation water, mmho/cm	<0.75	0.75 - 3.0	>3.0
Permeability			
EC of irrigation water, mmho/cm	>0.5	<0.5	<0.2
SAR, adjusted[c]	<6.0	6.0 - 9.0	>9.0
Specific ion toxicity from root absorption [d]			
Sodium (evaluate by adjusted SAR)	<3	3.0 - 9.0	>9.0
Chloride			
me/l	<4	4.0 - 10	>10
mg/l	<142	142 - 355	>355
Boron, mg/l	<0.5	0.5 - 2.0	2.0 - 10.0
Specific ion toxicity from foliar absorption[e](sprinklers)			
Sodium			
me/l	<3.0	>3.0	--
mg/l	<69	>69	--
Chloride			
me/l	<3.0	>3.0	--
mg/l	<106	>106	--
Miscellaneous[f]			
NH4 - N, mg/l for sensitive crops	<5	5 - 30	>30
NO3 - N, mg/l for sensitive crops	<5	5 - 30	>30
HCO3 (only with overhead sprinklers)			
me/l	<1.5	1.5 - 8.5	>8.5
mg/l	<90	90 - 520	>520
pH	Normal range	6.5 - 8.4	--

a Interpretations are based on possible effects of constituents on crops and/or soils. Guidelines are flexible and should be modified when warranted by local experience or special conditions of crop, soil, and method of irrigation.

b Assumes water for crop plus needed water for leaching requirement (LR) will be applied. Crops vary in tolerance to salinity. Refer to tables for crop tolerance and LR. The mmho/cm x 640 = approximate total dissolved solids (TDS) in mg/l or ppm; mmho x 1,000 = micromhos.

c Adjusted SAR (sodium adsorption ratio) is calculated from a modified equation developed by U.S. Salinity Laboratory to include added effects of precipitation and dissolution of calcium in soils and related to CO_3 + HCO_3 concentrations.

To evaluate sodium (permeability) hazard: Adjusted SAR = $Na/[1/2\ (Ca + Mg)]^{1/2}[1+ (8.4 - pHc)]$.
Refer to Appendix for calculation assistance.

SAR can be reduced if necessary by adding gypsum. Amount of gypsum required (GR) to reduce a hazardous SAR to any desired SAR (SAR desired) can be calculated as follows:

$$GR = \left[\frac{2(Na)^2}{SAR^2\, desired} - (Ca + Mg) \right] 234$$

Note: Na and Ca + Mg should be in me/l. GR will be in lbs. of 100 percent gypsum per acre foot of applied water.

d Most tree crops and woody ornamentals are sensitive to sodium and chloride (use values shown). Most annual crops are not sensitive (use salinity tolerance tables). For boron sensitivity, refer to boron tolerance tables.

e Leaf areas wet by sprinklers (rotating heads) may show a leaf burn due to sodium or chloride absorption under low humidity/high evaporation conditions. (Evaporation increases ion concentration in water films on leaves between rotations of sprinkler heads.)

f Excess N may affect production or quality of certain crops; e.g., sugar beets, citrus, avocados, apricots, etc.
(1 mg/l NO_3 - N = 2.72 lbs. N/acre foot of applied water.) HCO_3 with overhead sprinkler irrigation may cause a white carbonate deposit to form on fruit and leaves.

Table 3-4. Water Quality Objectives for Agricultural Water Use

ELEMENT	Maximum Concentration (mg/l)[a] Irrigation supply[b]	Livestock watering
Aluminum	5.0	5.0
Arsenic	0.1	0.2
Beryllium	0.1	--
Boron	0.75	5.0
Cadmium	0.01	0.05
Chromium	0.10	1.0
Cobalt	0.05	1.0
Copper	0.2	0.5
Fluoride	1.0	2.0
Iron	5.0	--
Lead	5.0	0.1[c]
Lithium	2.5[d]	--
Manganese	0.2	--
Mercury	--	0.01
Molybdenum	0.01	0.5
Nickel	0.2	--
Nitrate + Nitrite	--	100
Nitrite	--	10
Selenium	0.02	0.05
Vanadium	0.1	0.10
Zinc	2.0	25

a. Values based primarily on "Water Quality Criteria 1972" National Academy of Sciences-National Academy of Engineers, Environmental Study Board, ad hoc Committee on Water Quality Criteria furnished as recommended guidelines by University of California Agriculture Extension Service, January 7, 1974; maximum values are to be considered as 90 percentile values not to be exceeded.

b. Values provided will normally not adversely affect plants or soils; no data available for mercury, silver, tin, titanium, and tungsten.

c. Lead is accumulative and problems may begin at threshold value (0.05 mg/l).

d. Recommended maximum concentration for irrigation citrus is 0.075 mg/l.

Bacteria

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200/100 ml, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 ml.

NON-CONTACT WATER RECREATION (REC-2)

pH

The pH value shall neither be depressed below 6.5 nor raised above 8.3.

Bacteria

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 2000/100 ml, nor shall more than ten percent of samples collected during any 30-day period exceed 4000/100 ml.

COLD FRESHWATER HABITAT (COLD)

pH

The pH value shall not be depressed below 7.0 or raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.5 in fresh waters.

Dissolved Oxygen

The dissolved oxygen concentration shall not be reduced below 7.0 mg/l at any time.

Temperature

At no time or place shall the temperature be increased by more than 5oF above natural receiving water temperature.

Chemical Constituents

Waters shall not contain concentrations of chemical constituents known to be deleterious to fish or wildlife in excess of the limits listed in Table 3-5.

WARM FRESHWATER HABITAT (WARM)

pH

The pH value shall not be depressed below 7.0 or raised above 8.5.

Changes in normal ambient pH levels shall not exceed 0.5 in fresh waters.

Dissolved Oxygen

The dissolved oxygen concentration shall not be reduced below 5.0 mg/l at any time.

Temperature

At no time or place shall the temperature of any water be increased by more than 5oF above natural receiving temperature.

Chemical Constituents

Waters shall not contain concentrations of chemical constituents known to be deleterious to fish or wildlife in excess of the limits listed in Table 3-5.

FISH SPAWNING (SPWN)

Cadmium

Cadmium shall not exceed .003 mg/l in hard water or .0004 mg/l in soft water at any time. (Hard water is defined as water exceeding 100 mg/l CaCO3.)

Dissolved Oxygen

The dissolved oxygen concentration shall not be reduced below 7.0 mg/l at any time.

Table 3-5. Toxic Metal Concentrations not to be Exceeded in Aquatic Life Habitats, mg/l[a,b]

METAL	Freshwater (COLD, WARM) HARD (> 100 mg/l CaCO3)	SOFT (< 100 mg/l CaCO3)
Cadmium[c]	.03	.004
Chromium	.05	.05
Copper	.03	.01
Lead	.03	.03
Mercury[d]	.0002	.0002
Nickel[e]	.4	.1
Zinc	.2	.004

a. Based on limiting values recommended in the National Academy of Sciences-National Academy of Engineers "Water Quality Criteria 1972." Values are 90 percentile values except as noted in qualifying note "d."

b. Revision of Table 3-5 is currently in progress by the Regional Board.

c. Lower cadmium values not to be exceeded for crustaceans and waters designated SPWN are 0.003 mg/l in hard water and 0.0004 mg/l in soft water.

d. Total mercury values should not exceed 0.05 µg/l as an average value; maximum acceptable concentration of total mercury in any aquatic organism is a total B.O.D. burden of 0.5 µg/l wet weight.

e. Value cited as objective pertains to nickel salts (not pure metallic nickel).

MARINE HABITAT (MAR)

pH

The pH value shall not be depressed below 7.0 or raised above 8.5.

Changes in normal ambient pH levels shall not exceed 0.2 units.

Dissolved Oxygen

The dissolved oxygen concentration shall not be reduced below 7.0 mg/l at any time.

Chemical Constituents

Waters shall not contain concentrations of chemical constituents known to be deleterious to fish or wildlife in excess of limits listed in Table 3-6.

Table 3-6. Toxic Metal Concentrations Not to be Exceeded in Marine Habitats, mg/l[a]

METAL	MARINE (MAR)
Cadmium	.0002
Chromium	.05
Copper	.01
Lead	.01
Mercury[c]	.0001
Nickel[d]	.002
Zinc	.02

a. Based on limiting values recommended in the National Academy of Sciences-National Academy of Engineers "Water Quality Criteria 1972." Values are 90 percentile values except as noted in qualifying note "c."
b. Revision of Table 3-6 is currently in progress by the Regional Board.
c. Total mercury values should not exceed 0.05 µg/l as an average value; maximum acceptable concentration of total mercury in any aquatic organism is a total B.O.D. burden of 0.05 µg/l net weight.
d. Value cited as objective pertains to nickel salts (not pure metallic nickel).

SHELLFISH HARVESTING (SHELL)

Chromium

The maximum permissible value for waters designated SHELL shall be 0.01 mg/l.

Bacteria

At all areas where shellfish may be harvested for human consumption, the median total coliform concentration throughout the water column for any 30-day period shall not exceed 70/100 ml, nor shall more than ten percent of the samples collected during any 30-day period exceed 230/100 ml for a five-tube decimal dilution test or 330/100 ml when a three-tube decimal dilution test is used.

II.A.3. WATER QUALITY OBJECTIVES FOR SPECIFIC INLAND SURFACE WATERS, ENCLOSED BAYS AND ESTUARIES

Certain water quality objectives have been established for selected surface waters; these objectives are intended to serve as a water quality baseline for evaluating water quality management in the basin. Median values, shown in Table 3-7 for surface waters, are based on available data.

It must be recognized that the median values indicated in Table 3-7 are values representing gross areas of a water body. Specific water quality objectives for a particular area may not be directly related to the objectives indicated. Therefore, application of these objectives must be based upon consideration of the surface and ground water quality naturally present; i.e., waste discharge requirements must adhere to the previously stated objectives and issuance of requirements must be tempered by consideration of beneficial uses within the immediate influence of the discharge, the existing quality of receiving waters, and water quality objectives. Consideration of beneficial uses includes: (1) a specific enumeration of all beneficial uses potentially to be affected by the waste discharge, (2) a determination of the relative importance of competing beneficial uses, and (3) impact of the discharge on existing beneficial uses. The Regional Board will make a judgment as to the priority of dominant use and minimize the impact on competing uses while not allowing the discharge to violate receiving water quality objectives.

Table 3-7. Surface Water Quality Objectives, mg/l[a]

Sub-Basin/Sub-Area	TDS	Cl	SO4	B	Na
Santa Ynez					
Cachuma Reservoir	600	20	220	0.4	50
Solvang	700	50	250	0.4	60
Lompoc	1000	100	350	0.4	100
Santa Maria					
Cuyama River (Near Garey)	900	50	400	0.3	70
Sisquoc River (Near Garey)	600	20	250	0.2	50
Estero Bay					
Santa Rosa Creek	500	50	80	0.2	50
Chorro Creek	500	50	50	0.2	50
San Luis Obispo Creek	650	100	100	0.2	50
Arroyo Grande Creek	800	50	200	0.2	50
Salinas River					
Salinas River					
Above Bradley	250	20	100	0.2	20
Above Spreckles	600	80	125	0.2	70
Gabilan Tributary	300	50	50	0.2	50
Diablo Tributary	1200	80	700	0.5	150
Nacimiento River	200	20	50	0.2	20
San Antonio River	250	20	80	0.2	20
Carmel River	200	20	50	0.2	20
Monterey Coastal					
Big Sur River	200	20	20	0.2	20
Pajaro River					
at Chittenden	1000	250	250	1.0	200
San Benito River	1400	200	350	1.0	250
Llagas Creek	200	10	20	0.2	20
Big Basin					
Boulder Creek	150	10	10	0.2	20
Zayante Creek	500	50	100	0.2	40
San Lorenzo River					
Above Bear Creek	400	60	80	0.2	50
At Tait Street Check Dam	250	30	60	0.2	25

a Objectives shown are annual mean values. Objectives are based on preservation of existing quality or water quality enhancement believed attainable following control of point sources.

As part of the State's continuing planning process, data will be collected and numerical water quality objectives will be developed for those mineral and nutrient constituents where sufficient information is presently not available for the establishment of such objectives.

II.A.4. OBJECTIVES FOR GROUND WATER

II.A.4.a. GENERAL OBJECTIVES

The following objectives apply to all ground waters of the basin.

Tastes and Odors

Ground waters shall not contain taste or odor producing substances in concentrations that adversely affect beneficial uses.

Radioactivity

Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life; or result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal, or aquatic life.

MUNICIPAL AND DOMESTIC SUPPLY (MUN)

Bacteria

The median concentration of coliform organisms over any seven-day period shall be less than 2.2/100 ml.

Organic Chemicals

Ground waters shall not contain concentrations of organic chemicals in excess of the limiting concentrations set forth in California Code of Regulations, Title 22, Chapter 15, Article 5.5, Section 64444.5, Table 5 and listed in Table 3-1.

Chemical Constituents

Ground waters shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 4, Section 64435, Tables 2 and 3.

Radioactivity

Ground waters shall not contain concentrations of radionuclides in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 5, Section 64443, Table 4.

AGRICULTURAL SUPPLY (AGR)

Ground waters shall not contain concentrations of chemical constituents in amounts that adversely affect such beneficial use. Interpretation of adverse effect shall be as derived from the University of California Agricultural Extension Service guidelines provided in Table 3-3.

In addition, water used for irrigation and livestock watering shall not exceed the concentrations for those chemicals listed in Table 3-4. No controllable water quality factor shall degrade the quality of any ground water resource or adversely affect long-term soil productivity. The salinity control aspects of ground water management will account for effects from all sources.

II.A.5. OBJECTIVES FOR SPECIFIC GROUND WATERS

Certain water quality objectives have been established for selected ground waters; these objectives are intended to serve as a water quality baseline for evaluating water quality management in the basin. The median values for ground waters are shown in Table 3-8.

The restrictions specified for Table 3-7 are applicable to the values indicated in Table 3-8; i.e., the values are at best representative of gross areas only. Ground waters in the Upper Valley of the Salinas River Sub-basin have average Total Dissolved Solids (TDS) concentrations that range from 300 mg/l to over 3000 mg/l. Therefore, application of these objectives must be consistent with the objectives previously stated in this chapter and synchronously reflect the actual ground water

quality naturally present. The Regional Board must afford full consideration to: (1) present and probable future beneficial uses affected by the waste discharge; (2) competing beneficial uses; (3) degree of impact on existing beneficial uses; (4) receiving water quality; and (5) water quality objectives, before adjudging priority of dominant use and promulgating waste discharge requirements.

As part of the State's continuing planning process, data will be collected and numerical water quality objectives will be developed for those mineral constituents where sufficient information is presently not available for the establishment of such objectives.

Table 3-8. Median Ground Water Objectives, mg/l[a]

Sub-basin/Sub-Area	TDS	Cl	SO_4	B	Na	N[b]
South Coast						
Goleta	1000	150	250	0.2	150	5
Santa Barbara	700	50	150	0.2	100	5
Carpinteria	700	100	150	0.2	100	7
Santa Ynez						
Santa Ynez	600	50	10	0.5	20	1
Santa Rita	1500	150	700	0.5	100	1
Lompoc Plain[f]	1250	250	500	0.5	250	2
Lompoc Upland[f]	600	150	100	0.5	100	2
Lompoc Terrace[f]	750	210	100	0.3	130	1
San Antonio Creek	600	150	150	0.2	100	5
Santa Maria[c]						
Upper Guadalupe[f]	1000[d]	165	500[d]	0.5	230	1.4[e]
Lower Guadalupe[f]	1000[d]	85	500[d]	0.2	90	2.0[e]
Lower Nipomo Mesa[f]	710	95	250	0.15	90	5.7[e]
Orcutt[f]	740	65	300	0.1	65	2.3[e]
Santa Maria[f]	1000[d]	90	510	0.2	105	8.0[e]
Cuyama Valley	1500	80	--	0.4	--	5
Soda Lake	[e]	[e]	[e]	[e]	[e]	[e]
Estero Bay						
Santa Rosa	700	100	80	0.2	50	5
Chorro	1000	250	100	0.2	50	5
San Luis Obispo	900	200	100	0.2	50	5
Arroyo Grande	800	100	200	0.2	50	10
Salinas River						
Upper Valley[f]	600	150	150	0.5	70	5
Upper Forebay[f]	800	100	250	0.5	100	5
Lower Forebay[f]	1500	250	850	0.5	150	8
180 foot Aquifer[f]	1500	250	600	0.5	250	1
400 foot Aquifer[f]	400	50	100	0.2	50	1
Paso Robles[g]						
Central Basin[f]	400	60	45	0.3	80	3.4
San Miguel[f]	750	100	175	0.5	105	4.5
Paso Robles[f]	1050	270	200	2.0	225	2.3
Templeton[f]	730	100	120	0.3	75	2.7
Atascadero[f]	550	70	85	0.3	65	2.3
Estrella[f]	925	130	240	0.75	170	3.2
Shandon	1390	430	1025[h]	2.8	730	2.3
Pajaro River						
Hollister	1200	150	250	1.0	200	5
Tres Pinos	1000	150	250	1.0	150	5
Llagas	300	20	50	0.2	20	5
Big Basin						
Near Felton	100	20	10	0.2	10	1
Near Boulder Creek	250	30	50	0.2	20	5

a Objectives shown are median values based on data averages; objectives are based on preservation of existing quality or water quality enhancement believed attainable following control of point sources.
b Measured as Nitrogen
c Basis for objectives is in the "Water Quality Objectives for the Santa Maria Ground Water Basin Revised Staff Report, May 1985" and February 1986, Staff Report.
d These are maximum objectives in accordance with Title 22 of the Code of Regulations.
e Ground water basin currently exceeds usable mineral quality.
f Ground water basin boundary map available in appendix.
g Basis for objectives is in the report "A Study of the Paso Robles Ground Water Basin to Establish Best Management Practices and Establish Salt Objectives", Coastal Resources Institute, June 1993.
h Standard exceeds California Secondary Drinking Water Standards contained in Title 22 of the Code of Regulations. Water quality standard is based upon existing water quality. If water quality degradation occurs, the Regional Board may consider salt limits on appropriate discharges.

CHAPTER 4. IMPLEMENTATION PLAN

A program of implementation to protect beneficial uses and to achieve water quality objectives is an integral component of this Basin Plan. The program of implementation is required to include, but is not limited to:

- A description of the nature of actions which are necessary to achieve the objectives, including recommendations for appropriate action by any entity, public or private.
- A time schedule for the actions to be taken.
- A description of surveillance to be undertaken to determine compliance with objectives.

Additional surveillance activities to determine compliance with objectives are described in Chapter Six, "Surveillance and Monitoring".

This chapter includes discussions of:

- Regional Water Quality Control Board Goals;
- General Control Actions and Related Issues;
- Waste Discharge Regulation;
- Hazardous Waste Compliance Issues; and
- Nonpoint Source Measures.

Detailed descriptions of waterbodies with their specific water quality problems and recommended control actions are included in the Region's Water Quality Assessment database and Fact Sheets.

This chapter is organized in the following manner:

I. Regional Water Quality Control Board Goals
II. General Control Actions and Related Issues
III. Control Actions under State Board Authority
IV. Control Actions to be Implemented by Other Agencies with Water Quality or Related Authority
V. Control Actions under Regional Board Authority
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      3. Waste Discharge Requirements
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      4. Land Disposal
      5. Reclamation and Reuse
      6. Pretreatment Programs
      7. Sludge Treatment
   B. Municipal Wastewater Management Plans (arranged by hydrologic subarea)
   C. Industrial Wastewater Management
   D. Solid Waste Management
   E. Storm Water Management
   F. Bay Protection and Toxic Cleanup Program
   G. Military Installations
   H. Spills, Leaks, Investigations, and Cleanup Program
   I. Underground Tank Storage Tank Program
   J. Aboveground Petroleum Storage Tanks
   K. California Code of Regulations, Title 23, Chapter 15
      1. Solid and Liquid Waste Requirements (Landfills and Surface Impoundments)
      2. Wastewater Sludge (Septage Management)
      3. Mining Activities (Nonfuel Commodities)
      4. Other Industrial Activities
   L. Resource Conservation and Recovery Act (Subtitle D)
   M. Solid Waste Water Quality Assessment Test
VII. Hazardous Waste Compliance Issues
   A. Reportable Quantities of Hazardous Waste and Sewage Discharges
   B. Proposition 65
VIII. Nonpoint Source Measures
   A. Coastal Zone Act Reauthorization Amendments
   B. Urban Runoff Management
   C. Agricultural Water and Wastewater Management
   D. Individual, Alternative, and Community Disposal Systems
   E. Land Disturbance Activities

I. REGIONAL WATER QUALITY CONTROL BOARD GOALS

To insure that the water resources of the Central Coastal Basin are preserved for future generations of Californians, the California Regional Water Quality Control Board, Central Coast Region, determined it was desirable to establish certain planning goals. These goals pertain to utilization of the basin's water resources and guidelines for control of waste discharges, as follows:

1. Protect and enhance all basin waters, surface and underground, fresh and saline, for present and anticipated beneficial uses, including aquatic environmental values.

2. The quality of all surface waters shall allow unrestricted recreational use.

3. Manage municipal and industrial wastewater disposal as part of an integrated system of fresh water supplies to achieve maximum benefit of fresh water resources for present and future beneficial uses and to achieve harmony with the natural environment.

4 Achieve maximum effective use of fresh waters through reclamation and recycling.

5. Continually improve waste treatment systems and processes to assure consistent high quality effluent based on best economically achievable technology.

6. Reduce and prevent accelerated (man-caused) erosion to the level necessary to restore and protect beneficial uses of receiving waters now significantly impaired or threatened with impairment by sediment.

II. GENERAL CONTROL ACTIONS AND RELATED ISSUES

The Regional Water Quality Control Board (Regional Board) regulates the sources of water quality related problems which could result in actual or potential impairment or degradation of beneficial uses or degradations of water quality. The Regional Board regulates both point and nonpoint source discharge activities. A point source discharge generally originates from a single identifiable source, while a nonpoint source discharge comes from diffuse sources. To regulate the point and nonpoint sources, control actions are required for effective water quality protection and management. Such control actions are set forth for implementation by the State Water Resources Control Board (State Board), by other agencies with water quality or related authority, and by the Regional Board.

III. CONTROL ACTIONS UNDER STATE WATER RESOURCES CONTROL BOARD AUTHORITY

The State Board has adopted several water quality plans and policies which complement or may supersede portions of the Water Quality Control Plan. These plans and policies may include specific control measures. See Chapter Five, "Plans and Policies" for summaries of the most significant State Board plans and policies which affect the Central Coast Region.

IV. CONTROL ACTIONS TO BE IMPLEMENTED BY OTHER AGENCIES WITH WATER QUALITY OR RELATED AUTHORITY

Water quality Management Plans prepared under Section 208 of the federal Water Pollution Water Control Act (Clean Water Act) have been prepared by various public agencies. These Section 208 plans, as well as other plans adopted by federal, State, and local agencies, may affect the Regional Board's water quality management and control activities. A summary of relevant water quality management plans is included in Chapter Five, "Plans and Policies".

V. CONTROL ACTIONS UNDER REGIONAL BOARD AUTHORITY

Control measures implemented by the Regional Board must provide for the attainment of this Basin Plan's beneficial uses and water quality objectives. These uses and objectives can be found in Chapters Two and Three, respectively. In addition the control measures must be consistent with State Board and Regional Board plans, policies, agreements, prohibitions, guidance, and other restrictions and requirements contained within this document.

To prevent water quality problems, waste discharge restrictions are often used. The waste discharge restrictions can be implemented through Water Quality Certification, National Pollutant Discharge Elimination System (NPDES) permits, waste discharge requirements/permits (WDRs), discharge prohibitions, enforcement actions, and/or "Best Management Practices".

V.A. WASTE DISCHARGE RESTRICTIONS

V.A.1. WATER QUALITY CERTIFICATION

Clean Water Act Section 401 Water Quality Certification gives the State extremely broad authority to review proposed federal activities in and/or affecting the Region's waters. The Regional Board can recommend to the State Board that it grant, deny, or condition certification of federal permits or licenses that may result in a discharge to "waters of the United States".

V.A.2. NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

NPDES permits are issued to regulate discharges of waste from point sources to "waters of the United States" including discharges of storm waters from urban separate storm sewer systems and certain categories of industrial activity. Waters of the United States are surface waters such as rivers, intermittent streams, dry stream beds, lakes, bays, estuaries, oceans, etc. The permits are authorized by Section 402 of the Clean Water Act and Section 13370 of the California Porter-Cologne Water Quality Control Act. The permit content and the issuance process are contained in 40 Code of Federal Regulations Part 122 and Chapter 9 of the California Code of Regulations. Regional Water Boards are authorized to take a variety of enforcement actions to obtain compliance with an NPDES permit. Enforcement actions the Regional Board may take are described below.

The U.S. Environmental Protection Agency (U.S. EPA) has approved the State's program to regulate discharges of waste water from point sources to "waters of the United States". The State , through the Regional Water Boards, issues the NPDES permits, reviews discharger self-monitoring reports,

performs independent compliance checking, and takes enforcement actions as needed.

NPDES permits are required to prescribe conditions of discharge which will ensure protection of beneficial uses of the receiving water. The Regional Board uses this Basin Plan, the Ocean Plan, and water quality control policies adopted by the State Board to develop permits for specific types of discharges or uses of waste water.

In addition to regulating discharges of waste water to surface waters, NPDES permits also require municipal sewage treatment systems to conduct pretreatment programs if their design capacity is greater than five million gallons per day. Smaller municipal treatment systems may be required to conduct pretreatment programs if there are significant industrial users of their systems. The pretreatment programs must comply with 40 Code of Federal Regulations Part 403. The pretreatment program is further described under separate heading in the "Waste Discharge Regulation" Section further in this chapter.

V.A.3. WASTE DISCHARGE REQUIREMENTS (WDRs)

The California Porter-Cologne Water Quality Control Act authorizes Regional Boards to regulate discharges to protect ground and surface water quality. Regional Boards issue WDRs in accordance with Section 13263 of the California Porter-Cologne Water Quality Control Act. Regional Boards are required to review WDRs periodically based on the complexity and threat to water quality. WDRs seek to protect the beneficial uses of ground and surface water. Regional Boards issue WDRs, review self-monitoring reports submitted by the discharger, perform independent compliance checking, and take necessary enforcement action. The California Porter-Cologne Water Quality Control Act authorizes Regional Boards to issue enforcement actions (see below) ranging from orders requiring relatively simple corrective action to monetary penalties in order to obtain compliance with WDRs.

V.A.4. WAIVERS

Regional Boards may waive issuance of WDRs pursuant to California Porter-Cologne Water Quality Control Act Section 13269 if the Regional Board determines that such waiver is in the public interest. The requirement to submit a Report of Waste Discharge can also be waived. WDRs can be waived for a specific discharge or types of discharges. A waiver of WDRs is conditional and may be terminated at any time by the Regional Board. Regional Boards may delegate their power to waive WDRs to the Regional Board Executive Officer in accordance with policies adopted by the Regional Board and approved by the State Board. The Regional Board's general policy regarding waivers is described in Chapter Five, "Plans and Policies". Regional Boards may not waive NPDES permits.

V.A.5. PROHIBITIONS AND PROHIBITION EXEMPTIONS

The Regional Board can prohibit specific types of discharges to certain areas (California Porter-Cologne Water Quality Control Act Section 13243). These discharge prohibitions may be revised, rescinded, or adopted as necessary. Discharge prohibitions are described in pertinent sections of Chapter Four, "Implementation Plan" and Chapter Five, "Plans and Policies" in the Regional Board Discharge Prohibition Section. Prohibitions can be found by referring to the Table of Contents.

V.A.6. ENFORCEMENT ACTIONS

To facilitate water quality problem remediation or Basin Plan violation remediation, the Regional Board can use different types of enforcement measures. These measures can include:

<u>Notice of Violation</u>

A Notice of Violation is a letter formally advising the discharger that the facility is in noncompliance and

that additional enforcement actions may be necessary, if appropriate actions are not taken.

Time Schedule

A Time Schedule (California Porter-Cologne Water Quality Control Act Section 13300) is a time schedule for specific actions a discharger shall take to correct or prevent violations of requirements. A Time Schedule is issued by the Regional Board for situations in which the Regional Board is reasonably confident that the problem will be corrected.

Cleanup or Abatement Order

A Cleanup or Abatement Order (California Porter-Cologne Water Quality Control Act Section 13304) is an order requiring a discharger to clean up a waste or abate its effects or, in the case of a threatened pollution or nuisance, take other necessary remedial action. A Cleanup or Abatement Order can be issued by the Regional Board or by the Regional Board Executive Officer. Cleanup or Abatement Orders are issued for situations when action is needed to correct a problem caused by regulated or unregulated discharges which are creating or threatening to create a condition of pollution or nuisance. A Cleanup or Abatement Order is also used by the Regional Board to establish the acceptable level of cleanup.

Cease and Desist Order

A Cease and Desist Order (California Porter-Cologne Water Quality Control Act Section 13301) is an order requiring a discharger to comply with Waste Discharge Requirements or prohibitions according to a time schedule. If the violation is threatening water quality, a Cease and Desist Order can be used to require appropriate remedial or preventative action. A Cease and Desist Order is issued by the Regional Board when violations of requirements or prohibitions are threatened, are occurring, or have occurred and probably will continue in the future. Issuance of a Cease and Desist Order requires a public hearing.

Administrative Civil Liabilities

Administrative Civil Liabilities (monetary liabilities or fines) may also be imposed administratively by the Regional Board after a public hearing.

State Attorney General Referral

State Attorney General referral is used under certain circumstances. Enforcement actions may be referred to either the General or District Attorney.

V.A.7. BEST MANAGEMENT PRACTICES

Property owners, managers, or other dischargers may implement "Best Management Practices" to protect water quality. (Implementation and enforcement of Best Management Practices are discussed below under the "Nonpoint Source Measures" section of this chapter). The term "Best Management Practices" is used in reference to control measures for nonpoint source water pollutants and is analogous to the terms "Best Available Technology/Best Control Technology" used for control of point source pollutants. The U.S. EPA (40 Code of Federal Regulations Section 103.2[m]) defines Best Management Practices as follows:

> "Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. Best Management Practices include, but are not limited to structural and nonstructural controls and operation and maintenance procedures. Best Management Practices can be applied before, during, and after pollution producing activities to reduce or eliminate the introduction of pollutants into receiving waters."

U.S. EPA regulations (40 Code of Federal Regulations Section 103.6[b][4][i]) provide that Basin Plans:

> "...shall describe the regulatory and nonregulatory programs, activities, and Best Management Practices which the agency has selected as the means to control nonpoint source pollution where necessary to protect or achieve approved water uses. Economic, institutional, and technical factors shall be considered in a continuing process of identifying control needs and evaluating and modifying the Best Management Practices as necessary to achieve water quality goals."

Best Management Practices fall into two general categories:

1. Source controls which prevent a discharge or threatened discharge.

These may include measures such as recycling of used motor oil, fencing stream banks to prevent livestock entry, fertilizer management, street cleaning, revegetation and other erosion controls, and limits on total impervious surface coverage. Because the effectiveness of Best Management Practices is often uncertain, source control is generally preferable to treatment. It is also often less expensive.

2. Treatment controls which remove pollutants from a discharge before it reaches surface or ground waters.

Examples include infiltration facilities, oil/water separators, and constructed wetlands.

Several important points about Best Management Practices must be emphasized;

- Best Management Practices are not officially considered "best" practices for use in California unless they have been certified by the State Board.

- The use of Best Management Practices does not necessarily ensure compliance with effluent limitations or with receiving water objectives. Because nonpoint source control has been a priority only since the 1970's, the long-term effectiveness of some Best Management Practices has not yet been documented. Some source control Best Management Practices (e.g., waste motor oil recycling) may be 100 percent effective if implemented properly. Monitoring and evaluation of Best Management Practice effectiveness is an important part of nonpoint source control programs.

- The selection of individual Best Management Practices must take into account specific site conditions (e.g., depth to ground water, quality of runoff, infiltration rates). Not all Best Management Practices are applicable at every location. High ground water levels may preclude the use of runoff infiltration facilities, while steep slopes may limit the use of wet ponds.

- To be effective, most Best Management Practices must be implemented on a long term basis. Structural Best Management Practices (e.g., wet ponds and infiltration trenches) require periodic maintenance, and may eventually require replacement.

- The "state-of-the-art" for Best Management Practices design and implementation is expected to change over time. The State planning process will include periodic review and update of Best Management Practices certifications.

General information on recommended nonpoint source management practices is provided under different water quality problem categories throughout this chapter. For detailed information on the design, implementation, and effectiveness of specific Best Management Practices, the reader should consult the appropriate Best Management Practices Handbook for the project type or location.

V.A.8. COMPLIANCE SCHEDULES

The California Porter-Cologne Water Quality Control Act (Section 13242[b]) requires a Basin Plan's implementation program for achieving water quality objectives to include a "time schedule for the actions to be taken". Regional Board prohibitions are effective upon adoption, unless specifically mentioned otherwise. The Regional Board issues discharge permits. Each includes an effective date. (Often compliance is effective upon Regional Board adoption). Waste discharge permits for construction projects generally require implementation of Best Management Practices during and immediately after construction. Long-term maintenance of permanent Best Management Practices is expected. Regional Board enforcement orders for specific problems also generally include compliance schedules.

The 1975 Basin Plans included recommendations that specific studies be carried out by specific dates on community wastewater collection and treatment facilities needs in certain areas of the Central Coast Region. These plans also recommended that some communities construct specific facilities by the given dates. Most of these schedules were not met. Because expected year-to-year changes in availability of and priorities for funding will ensure that long term schedules are unrealistic, this Basin Plan does

not include such recommendations. Priorities are set on a short term basis for studies through the State Board's use of the Clean Water Strategy ranking system various grant programs, and for facilities construction through the State Board Division of Clean Water Programs needs assessment process for loans and grants. Once funding is allocated, completion schedules are set through the contract process.

V.B. NONPOINT SOURCE PROGRAM

Nonpoint source pollution has been identified as a major cause of water pollution throughout the United States, and the California Central Coast Region is no exception. Nonpoint sources of water pollution are generally defined as sources which are diffuse (spread out over a large area). These sources are not as easily regulated or controlled as are point sources. Nonpoint source pollution is caused by land use activities or anthropomorphic activities. Deposition of pollutants may occur in lakes, rivers, wetlands, coastal waters, or ground waters.

In order to address the nonpoint source pollution problem nationwide, the U.S. Congress incorporated Section 319 into the 1987 amendments to the Clean Water Act. By amending the Clean Water Act, Congress shifted the federal emphasis from nonpoint source pollution planning and problem identification to a new nonpoint source action program. Section 319 of the federal Clean Water Act required each state to develop a State Nonpoint Source Management Program describing the measures the State would take to address nonpoint sources of pollution. In November 1988, the State Water Resources Control Board adopted a Nonpoint Source Management Plan which outlined steps to initiate the systematic management of nonpoint sources in California. For effective management of nonpoint sources the Management Plan required:

- An explicit long-term commitment by the State Board and Regional Boards;
- More effective coordination of existing State Board and Regional Board nonpoint source related programs;
- Greater use of Regional Board regulatory authority coupled with nonregulatory Regional Board programs;
- Stronger links between the local, State, and federal agencies which have authority to manage nonpoint sources; and
- Development of new funding sources.

The 1988 State Board Nonpoint Source Management Plan advocates three approaches for addressing nonpoint source management:

1. Voluntary implementation of Best Management Practices

Property owners or managers may volunteer to implement Best Management Practices. Implementation could occur for economic reasons and/or through awareness of environmental benefits.

2. Enforcement of Best Management Practices

Although the California Porter-Cologne Water Quality Control Act constrains Regional Boards from specifying the manner of compliance with water quality standards, there are two ways in which Regional Boards can use their regulatory authorities to encourage implementation of Best Management Practices.

First, the Regional Board may encourage Best Management Practices by waiving adoption of waste discharge requirements on condition that discharges comply with Best Management Practices. Alternatively, the Regional Board may enforce Best Management Practices indirectly by entering into management agency agreements with other agencies which have the authority to enforce Best Management Practices.

The Regional Board will generally refrain from imposing effluent requirements on discharges that are implementing Best Management Practices in accordance with a waiver of waste discharger requirements, and approved Management Agency Agreements, or other State or Regional Board formal action.

3. Adoption of Effluent Limitations

The Regional Board can adopt and enforce requirements on the nature of any proposed or existing waste discharge, including discharges from

nonpoint sources. Although the Regional Board is precluded from specifying the manner of compliance with waste discharge limitations, in appropriate cases, limitations may be set at a level which, in practice, requires implementation of Best Management Practices.

Not all of the categories of nonpoint source pollution follow this three-tiered approach. For example, silviculture activities on non-federal lands are administered by the California Department of Forestry. The State Board has entered into a Management Agency Agreement with California Department of Forestry which allows the Regional Boards to review and inspect timber harvest plans and operations for implementation of Best Management Practices for protection of water quality.

The Regional Board approach to addressing or regulating categories of nonpoint source pollution is discussed in various sections throughout this chapter.

VI. WASTE DISCHARGE PROGRAM IMPLEMENTATION

Water Quality Control Plans to regulate wasteloads in the Central Coastal Basin have been developed to insure protection of beneficial uses of water described in Chapter Two, as well as water quality objectives described in Chapter Three.

VI.A. EFFLUENT LIMITS

Effluent limitations for disposal of wastes are based on water quality objectives for the area of effluent disposal and applicable State and federal policies and effluent limits. Water quality objectives and policies are based on beneficial uses established for receiving waters. Decisions in treatment process selection are discussed for four general disposal modes considered: stream disposal, estuarine disposal, ocean disposal, and land disposal. There is no discussion provided for disposal to lakes or confined sloughs since these water bodies are protected by discharge prohibitions. Separate discussions of treatment for wastewater reclamation and reuse and sludge processing and disposal are also provided.

Management Principles and Regional Board Policies contained in Chapter Five should be reviewed for further information concerning discharge to surface waters.

VI.A.1. STREAM DISPOSAL

Most streams in the Central Coastal Basin are ephemeral in character. During summer months, there is little or no flow in stream channels. In several instances, flow during the dry season is composed of irrigation runoff or, in a very few cases, wastewater treatment plant effluent. Usually, these flows infiltrate into the stream bed a short distance downstream of discharges. In such instances, the concept of receiving water assimilative capacity has little meaning. Disposal of wastewater in ephemeral streams must be accomplished in a manner that safeguards public health and prevents nuisance conditions. Where possible, discharges should be beneficial as stream flow augmentation. When recharge of a useful ground water basin occurs through stream channel recharge, impacts on ground water quality must be considered.

There are a few streams in the basin which flow on a year-round basis and support an inland fishery. Disposal of wastewater to such streams requires that essentially all oxygen demanding substances and toxicity be removed.

Principal factors governing treatment process selection for stream disposal are federal effluent limits, State public health regulations, and water quality requirements for beneficial use protection. As a minimum, secondary treatment, as defined by the Environmental Protection Agency (EPA), is required in all cases. Where rapid percolation occurs, conventional secondary treatment is currently adequate. EPA guidelines for best practicable treatment would also apply in these cases. Where water contact recreational use is to be protected, the

California Department of Health Services (DOHS) recommends coagulation, filtration, and disinfection providing a median coliform MPN of 2.2/100 ml. Detoxification is required where fishery protection is a concern. Detoxification would include effluent limits for identified toxicants, pursuant to Section 307 of the federal Water Pollution Control Act. Source control of specific toxicants may be necessary to comply with the Act.

VI.A.2. ESTUARINE DISPOSAL

Water quality objectives applying to estuaries are contained in Chapter Three.

Receiving waters considered estuaries are one of two groups: (1) shallow waters of an open bay, and (2) confined tidal estuaries or lagoons. Flushing action is usually present in a shallow open bay and natural dispersion and dilution is available on a limited scale. In confined waters, flushing action is limited or nonexistent except during high stream inflow or storms. Since these shorelines frequently are heavily developed and waters are extensively used, requirements for wastewater disposal into such areas are the most stringent of any for marine receiving waters. The "Water Quality Control Policy for Enclosed Bays and Estuaries of California," adopted by the State Water Resources Control Board, prohibits discharge of waste to most enclosed bays and estuaries in the State, unless the discharge will enhance water quality.

Water quality objectives in Chapter Three prevent discharges that could raise natural nutrient levels to an extent that nuisance algal blooms or other aquatic growths occur. Excessive eutrophication in coastal estuaries of California often is characterized by floating and stranded mats of green marine seaweeds Enteromorpha and Ulva. These algae generally grow on mud or other substrates in estuarine water and can produce nuisance conditions along shorelines. These algae have a high sulfur content and emit foul smelling hydrogen sulfide and mercaptans during decomposition. Caution should be given in determining control measures for estuaries, as many of the seasonal algal growths that occur on mud flats are natural and may not be significantly affected by waste discharges in the watershed. Where eutrophication problems are apparent, secondary treatment with denitrification, or phosphorus removal and disinfection should be provided prior to discharge.

VI.A.3. OCEAN DISPOSAL

Water quality objectives applicable to ocean waters are contained in Chapter Three.

Federal guidelines for secondary treatment apply to ocean discharges. The State Water Resources Control Board's Water Quality Control Plan for Ocean Waters of California (Ocean Plan) establishes effluent limits achievable by alternative processes, such as advanced primary treatment. The Ocean Plan contains water quality objectives, requirements for effluent quality and management of waste discharges, and discharge prohibitions (including Areas of Special Biological Significance). Effluent quality requirements establish limitations for grease and oil, solids, turbidity, pH, and toxicity. Limits are also established for heavy metals, chlorine residual, various chlorinated pesticides, PCBs, toxaphene and radioactivity outside the zone of initial dilution.

For municipal discharges, the Clean Water Act allows waiver of secondary treatment standards on a case-by-case basis. Secondary treatment waivers are further discussed as they apply to specific discharges in the following section on Municipal Wastewater Management. If full secondary treatment is required but funding is inadequate, treatment levels should be achieved through staged construction. Ocean Plan objectives can be achieved as an interim measure. Secondary treatment must be added later if a waiver is not issued, or if receiving water monitoring indicates additional treatment is necessary to protect ocean waters. Industrial wastewater management is discussed later in this chapter.

VI.A.4. LAND DISPOSAL

To protect ground water resources, the Regional Board allows few waste discharges to land. Those that are permitted are closely regulated under existing laws and regulations to maintain and to protect ground water quality and beneficial uses.

Disposal of waste to land in the Central Coast Region is regulated by California Code of Regulations, Title 23, Chapter 15; the federal Resource Conservation and Recovery Act; the Toxic Pits Cleanup Act; the Porter-Cologne Water Quality Control Act; and State Health Department Regulations. Types of land disposal operations being regulated by the Central Coast Region include landfills, surface impoundments, septage and sludge disposal, mining operations, confined animal facilities, and some oil field exploration and production facilities.

California Code of Regulations, Title 23, Chapter 15

All land disposal operations are regulated by Chapter 15. Formerly called Subchapter 15. This is the most significant regulation used by the Regional Board in regulating hazardous and nonhazardous waste treatment, storage, and disposal. These regulations include very specific siting, construction, monitoring, and closure requirements for all existing and new waste treatment, storage, and disposal facilities. Chapter 15 requires operators to provide assurances of financial responsibility for initiating and completing corrective action for all known or reasonably foreseeable releases from waste management units. Detailed technical criteria are provided for establishing water quality protection programs, and corrective action programs are mandated for releases from waste management units.

Resource Conservation and Recovery Act

The State implements Resource Conservation and Recovery Act's Subtitle C (Hazardous Waste Regulations for Treatment, Storage, and Disposal) through the Department of Toxic Substances Control and the Regional Boards. In August 1992, the U.S. EPA formally delegated the Act program implementation authority to Department of Toxic Substances Control. As described above, regulation of hazardous waste discharges is also included in California Code of Regulations, Title 23, Chapter 15. (Chapter 15 monitoring requirements were also amended in August 1991 so as to be equivalent to Act requirements). These will be implemented through the adoption of Waste Discharge Requirements for hazardous waste sites covered by the Act. The discharge requirements will then become part of a State Resource Conservation and Recovery Act permit issued by Department of Toxic Substances Control.

Federal regulations required by Resource Conservation and Recovery Act Subtitle D have been adopted for Municipal Solid Waste landfills (40 Code of Federal Regulations Parts 257 & 258). The California Integrated Waste Management Board is the State lead agency for Subtitle D implementation. The State Board and the California Integrated Waste Management Board received U.S. EPA State program approval. Delegation of authority for the State Board to implement Subtitle I (Underground Storage Tanks) will occur after U.S. EPA approval of the State's program application. (The Underground Storage Tank Section is discussed later in this chapter).

Toxic Pits Cleanup Act

The Toxic Pits Cleanup Act of 1984 required all impoundments containing liquid hazardous wastes or free liquids containing hazardous waste be retrofitted with a liner/leachate collection system, or dried out by July 1, 1988. Impoundments "dried out" were closed to remove all contaminants and/or to stabilize any residual contamination.

VI.A.4.a. WASTEWATER DISPOSAL

Principal factors affecting treatment process selection for land disposal are the nature of soils and ground waters in the disposal areas and, where irrigation is involved, the nature of crops. Wastewater characteristics of particular concern are total salt content, nitrate, boron, pathogenic organisms, and toxic chemicals. Where percolation alone is considered, the nature of underlying ground waters is of particular concern. Treatment processes should be tailored to insure that local ground waters are not degraded.

Nitrate removal is required in many cases where percolation is to usable ground water basins. Percolation basins operated in alternating wet and dry cycles can provide significant nitrogen removal through nitrification/denitrification processes in the soil column. Finer textured soils are more effective than coarse soils. Nitrate removal would not necessarily be required, and secondary treatment

may be adequate where recharge is for other purposes such as prevention of seawater intrusion or where soil percolation constraints do not require further treatment. Monitoring in the immediate vicinity of the disposal site is required in either case. Where the need for nitrate removal is not clear, removal could be considered at a possible future stage depending on monitoring results. Where well controlled irrigation is practiced, nitrate problems in the dry season will be controlled. Vegetative uptake will utilize soluble nitrates which would otherwise move into ground water under a percolation operation. Demineralization techniques or source control of total dissolved solids may be necessary in some inland areas where ground waters have been or may be degraded. Presence of excessive salinity, boron, or sodium could be a basis for rejection of crop irrigation with effluent.

State Health Department regulations, described in Title 22 of the California Code of Regulations, stipulate disinfection levels required for specific crops. In some cases, such as pasture for milking animals, the California Code of Regulations requires oxidation with disinfection to a median number of coliform organisms of 23 MPN/100 ml. Environmental Protection Agency guidelines for secondary treatment do not apply to land disposal cases. However, municipal treatment facilities must provide effective solids removal and some soluble organics removal for percolation bed operations and for reduction of nuisance in wastewater effluent irrigation operations. Disinfection requirements are dictated by the disposal method. Oxidation ponds may be cost-effective in some remote locations and may be equivalent to secondary treatment.

VI.A.5. RECLAMATION AND REUSE

Water shortages in California are resulting in increased demand for reclamation. Reclamation and reuse is encouraged where feasible and beneficial. Where practicable, land disposal by spray irrigation shall be accomplished by proper reclamation techniques rather than by over-irrigation. This will aid water shortages and maximize nutrient removal.

Treatment process selection for reclamation of wastewater is dependent upon the intended reuse. Where irrigation reuse or ground water recharge is intended, treatment requirements will depend on conditions described under land disposal. Clearly, the nature of the crop to be irrigated, soil percolation, and water characteristics are important considerations. Title 22 of the California Code of Regulations provides wastewater reclamation criteria to regulate specific uses of reclaimed water. Where reuse is extended to water contact recreation, secondary treatment with coagulation, filtration, and disinfection is required. Where golf course irrigation is practiced, this level of treatment minus coagulation and filtration may be adequate. More stringent measures may be necessary with increased risk of public exposure (for example, residents adjacent to fairways). However, where more complete reclamation is envisioned, such as creation of recreational lakes for fishing, swimming, and water skiing, nutrient removal may also be required to minimize algae growths and to encourage fish propagation. Comparable treatment may also be needed for industrial water supplies used for cooling and uses where algae growth in transfer channels or cooling towers is of concern. Nitrogen removal and demineralization processes may also be necessary for selected reclamation projects as discussed under land disposal.

To meet the increased demand for reclamation, existing regulations contained in the California Code of Regulations, Title 22, are being expanded. California Code of Regulations, Title 22, are hereby incorporated as applicable reclamation requirements.

Dual water systems may be feasible in some instances. Reclaimed wastewater should be investigated as an alternative water source for toilets.

Management Principles contained in Chapter Five should be reviewed for further reclamation information. This section is located after the "Recommended State Water Resources Control Board Actions" section.

VI.A.6. PRETREATMENT PROGRAMS

State and federal regulations require certain municipalities to develop and administer pretreatment programs to control the discharge of industrial wastes to the treatment plant. All municipal plants discharging to navigable waters with design flows greater than 5.0 mgd are required to develop and implement a pretreatment program. Other municipalities may be required to develop a pretreatment program if circumstances warrant such a program. The Environmental Protection Agency has established specific industrial subcategories of industries which discharge certain quantities or concentrations of pollutants to municipal systems. Pretreatment is required to meet effluent standards established for each industrial category. The objectives of a pretreatment program are to: (1) prevent introduction of pollutants into publicly-owned treatment works which will interfere with treatment operations and/or use or disposal of municipal sludge, (2) prevent introduction of pollutants into publicly owned treatment works which will pass through treatment works or be incompatible with treatment techniques, (3) increase feasibility of recycling and reclaiming municipal and industrial wastewaters and sludges, and (4) enforce applicable EPA Categorical Standards.

A pretreatment program must include: (1) a local pretreatment ordinance, (2) a use permit system, (3) a program of monitoring and inspection to insure compliance with the ordinance and use permit, and (4) an enforcement program sufficient to obtain compliance with provisions of the ordinance or use permit. Pretreatment programs are further discussed as they apply to specific dischargers in the section on Municipal Wastewater Management.

Municipalities required to comply with federal pretreatment regulations in the Central Coast Region are:

City of Santa Cruz,
Cities of Gilroy/Morgan Hill,
City of Watsonville,
Monterey Regional Wastewater Treatment Plant,
City of Salinas Industrial Plant,
City of San Luis Obispo,
City of Santa Maria,
City of Lompoc, and
City of Santa Barbara

VI.A.7. SLUDGE TREATMENT

Sludge management is a difficult aspect of wastewater treatment. The methods used for sludge disposal or reuse tend to determine the sludge processing methods. Major goals of sludge treatment include pathogen destruction, vector attraction reduction, odor reduction, moisture removal, and contaminant removal. Treated sludge is commonly referred to as "Biosolids."

Solids removed during wastewater treatment include grit, primary sludge, and biological sludges. Grit is typically removed in a grit chamber and is usually inert and easily dewatered, so landfilling is usually the preferred management option. Primary sludges are generally solids that readily float or sink, whereas biological sludges are suspended organic materials and necessitate biological treatment (e.g., trickling filter, activated sludge, or oxidation pond) to float or sink. Polymers are widely used to increase settling and thickening efficiencies and to reduce chemical sludge handling problems. Primary and biological sludges are usually combined prior to final treatment. Anaerobic digestion and lagoon stabilization are common sludge treatment methods, but methods which can render sludge pathogen and odor free, such as lime stabilization, composting, thermophylic aerobic digestion, and heat treatment, are becoming increasingly popular. Public acceptance of beneficial sludge uses, such as spreading on farm land and reclamation of strip mines, may be improved by advanced sludge treatment technologies.

Sludge treatment methods are evolving as disposal is discouraged and beneficial reuse is encouraged. Ocean disposal of sludge is prohibited by the California Ocean Plan. Landfilling of sludge is generally allowed if the sludge is nonhazardous and meets specific moisture content requirements. Sludge may be disposed in Class I and Class II waste management units, but this practice is uncommon

due to its high cost. Disposal of sludge is becoming less attractive as landfill capacity decreases, recycling mandates (Assembly Bill 939) must be met, and society becomes aware that sludge can be a valuable resource as a soil amendment/fertilizer.

VI.B. MUNICIPAL WASTEWATER MANAGEMENT

Municipal wastewater conveyance, treatment, and disposal facilities recommended for the Central Coastal Basin are described in the following pages. Recommended plans for municipal facilities are described in geographic sequence by hydrographic units. Hydrographic units are identified in Chapter Two, Figure 2-1. Numbers in parentheses throughout the chapter refer to design capacity unless otherwise stated. Pretreatment programs and modifications to secondary treatment are discussed as part of the recommended plan where applicable. Further discussion of these topics can be found under the subheadings "Ocean Disposal" and "Pretreatment Programs" at the beginning of this chapter.

Further specific municipal management information can be found in the Management Principles section of Chapter Five. General municipal wastewater management information is also included in the State Water Resources Control Board Plans and Policies section, Discharge Prohibitions section, Control Actions section, and Regional Board Policies section.

VI.B.1. BIG BASIN HYDROLOGIC UNIT

The Big Basin Hydrologic Unit includes discharges from the City of Santa Cruz and the City of Scotts Valley, in addition to unsewered areas and several small waste dischargers. Table 4-1 displays summarized Big Basin Hydrologic Unit dischargers.

Table 4-1. Big Basin Hydrologic Unit Summarized Municipal Dischargers

Davenport County Sanitation District
California Department of Parks and Recreation - Big Basin State Park
California Department of Forestry - Ben Lomond Conservation Facility
City of Santa Cruz
City of Scotts Valley
Santa Cruz County Service Area No. 7 - Boulder Creek Golf and Country Club
Santa Cruz County Service Area No. 10 - Rolling Woods Subdivision
San Lorenzo Valley Water District - Bear Creek Estates
Big Basin Woods
Santa Cruz County Service Area No. 5 - Sand Dollar Beach and Canon del Sol
Santa Cruz County Service Area No. 20 - Trestle Beach
Individual Septic Tank Systems

The City of Santa Cruz operates a wastewater collection, primary treatment, and ocean disposal system with a capacity of 21 mgd. Sewerage service is provided to the City of Santa Cruz, Santa Cruz County Sanitation District (SCCSD), and the City of Scotts Valley. The SCCSD serves East Cliff, Capitola, Aptos, and Seacliff areas. The recommended plan for the City is to upgrade the existing treatment plant at Neary's Lagoon to secondary level treatment. A new outfall was completed in 1988. The new outfall is 12,250 feet long terminating in 100 feet of water about one mile offshore. It replaces a 2,000 foot outfall which was a source of many complaints due to its proximity to the shore water-contact recreation area.

Mitigation measures to offset environmental impacts to Neary's Lagoon and an adjacent park must be resolved before the plant can proceed. The City has implemented a pretreatment program affecting the City of Santa Cruz, and Santa Cruz County Sanitation District.

Wastewaters from sewered areas of the City of Scotts Valley are transported to Scotts Valley's secondary treatment plant. Effluent is transported through a land outfall to the City of Santa Cruz marine outfall for disposal to the Pacific Ocean. A recommended plan for Scotts Valley includes: (1) increasing wastewater treatment capacity from 0.65

mgd to 0.95 mgd, (2) providing reclaimed water to Pasatiempo Golf Course and other green belt areas for irrigation purposes, and (3) transporting excess wastewater through the Scotts Valley land outfall to the City of Santa Cruz ocean outfall. An alternative plan is to transport raw wastewater through the Scotts Valley land outfall to the Santa Cruz wastewater treatment plant for treatment and disposal through the ocean outfall. Local water agencies (Scotts Valley Water District and San Lorenzo Valley Water District) may benefit from reclamation efforts and should be involved in reuse planning.

Davenport County Sanitation District (DCSD) was created in 1979 to provide sewer and water services to the Davenport-Newtown area located on the coast north of Santa Cruz. Davenport-Newtown area has interceptors and an aerated wastewater lagoon on property owned by Lone Star Industries. Disposal is through evaporation/ percolation and industrial reuse. DCSD is responsible for wastewater collection, treatment, and disposal.

The State Department of Parks and Recreation is responsible for Big Basin State Park facilities (.04 mgd). Discharge provides stream flow augmentation. The wastewater treatment plant includes secondary treatment with sand filtration and coagulation. This stream discharge qualifies as an acceptable wastewater reclamation project. The discharge is upstream from a popular swimming hole, so this plan emphasizes the need to enhance water quality and protect beneficial uses in Waddell Creek. The Department of Parks and Recreation must correct wastewater system deficiencies in order to protect public health and the beneficial uses of Waddell Creek and tributaries.

The recommended plan for the Ben Lomond Conservation Facility is to retain the existing septic tank, evaporation/percolation ponds, and spray field. Existing facilities are adequate so long as operation and maintenance are effective.

Wastewater management in San Lorenzo Valley (SLV) is provided by three community treatment and disposal facilities (Bear Creek Estates, Big Basin Woods, and Boulder Creek Golf and Country Club). Remaining areas are served by individually owned septic tank and soil absorption systems. Bear Creek Estates uses septic tank treatment with disposal to a soil absorption system. This facility is the responsibility of San Lorenzo Valley Water District and Bear Creek Estates.

The recommended plan for Big Basin Woods Subdivision is to retain the existing extended aeration treatment facility with leachfield disposal, presently operating at approximately ten percent of total capacity (.35 mgd). Flow from County Service Area No. 7 has been diverted to Big Basin Woods' leachfield during equipment repair periods. Leachfield capacity is adequate to serve both Big Basin Woods and CSA No. 7. Existing facilities are adequate so long as operation and maintenance are effective. This plan will be implemented by Big Basin Sanitation Company, Big Basin Woods Subdivision, and the San Lorenzo Valley Water District.

The recommended plan for Boulder Creek Golf and Country Club is to retain the existing activated sludge treatment facility with leachfield disposal and add filtration for golf course irrigation. Existing facilities are adequate so long as operation and maintenance are effective. Operation and maintenance of the system is the responsibility of the Santa Cruz County Department of Public Works. This plan will be implemented by Santa Cruz County Service Area No. 7 through Santa Cruz County Department of Public Works and San Lorenzo Valley Water District.

Rolling Woods Subdivision, Santa Cruz County Service Area No. 10, provides treatment with a redwood bark biofilter and disposes treated effluent through percolation pits. This facility should be replaced with an interceptor that would convey wastes to the City of Santa Cruz for treatment and disposal.

Individually owned septic tank leachfield systems in the San Lorenzo Valley have been inspected and monitored from 1986 through 1994. Problem areas have been identified and the suitability of these problem areas for the continued use of septic systems has been determined as documented in the County of Santa Cruz, Environmental Health Services reports (1) Preliminary Report, An Evaluation of Wastewater Disposal and Water Quality in the San Lorenzo Watershed, September, 1989; (2) Final Project Report, Boulder Creek Wastewater Feasibility Study, October, 1991; and (3) Final Project Report, San Lorenzo Valley Community Wastewater Feasibility Studies, March, 1994. Alternatives have been evaluated and solutions proposed to reduce septic system problems in certain areas of the valley. Solutions are contained in the “Wastewater Management Plan for the San Lorenzo River Watershed, County of Santa Cruz, Health Services Agency, Environmental Health Service”, February 1995 and “San Lorenzo Nitrate Management Plan,

Phase II Final Report", February 1995, County of Santa Cruz, Health Services Agency, Environmental Health Service (Wastewater Management Plan). The Wastewater Management Plan documented standards and conditions that shall be met for the protection and enhancement of beneficial uses.

Dischargers in the Aptos-Soquel area include Santa Cruz County Service Area No. 5 (Sand Dollar Beach and Canon del Sol), SCCSA No. 20 (Trestle Beach), and Monterey Bay Academy. Flows from Aptos and East Cliff are conveyed through interceptors and pumping stations for treatment at the City of Santa Cruz Wastewater Treatment Plant.

The recommended plan for SCCSA No. 5 is to retain the existing extended aeration package treatment plant and disposal to seepage pits. Wastewater treatment and disposal at Canon del Sol will be by the same methods as Sand Dollar Beach. Facilities will be adequate so long as operation and maintenance are effective. This plan will be implemented by SCCSA No. 5 through Santa Cruz County Department of Public Works.

Wastewater treatment at Trestle Beach (SCCSA No. 20) will be provided by an extended aeration package treatment plant with disposal to seepage pits. This plan will be implemented by SCCSA No. 20 through the Santa Cruz County Department of Public Works. It is recommended that CSA No. 5 and No. 20 be connected to regional collection systems when service is extended to adjacent areas.

The recommended plan for the Monterey Bay Academy is to retain the existing settling pond with disposal to a series of evaporation-percolation ponds.

VI.B.2. PAJARO RIVER HYDROLOGIC UNIT

Summarized municipal dischargers in the Pajaro River Hydrologic Unit include the City of Gilroy/ Morgan Hill, City of Hollister, City of San Juan Bautista, and the City of Watsonville. Table 4-2 displays dischargers summarized for the Pajaro River Hydrologic Unit.

Table 4-2. Pajaro River Hydrologic Unit Summarized Municipal Dischargers

Unsewered San Martin
City of Gilroy/Morgan Hill
San Benito County Facilities
Sunnyslope County Water District
Tres Pinos County Water District
City of Hollister
City of San Juan Bautista
City of Watsonville

The Gilroy area includes the unsewered San Martin area and the City of Gilroy's advanced primary treatment and land disposal facilities serving the Cities of Gilroy and Morgan Hill. The Cities are currently attempting to develop facilities to resolve disposal capacity deficiencies. Primary treatment provided via two oxidation ponds with surface aeration. Effluent disposal is to a series of evaporation/percolation ponds. Wastewater reclamation facilities were constructed in 1977 to alleviate water shortages during drought conditions. When reclamation facilities are in use (seasonally), primary effluent is provided further treatment in an aeration pond. Effluent is then screened, chlorinated, and pumped through nine miles of distribution pipe to various users (for irrigation purposes). The reclamation system's economics have not been favorable. Industrial flows of 6.3 mgd are treated and disposed of in a separate series of sedimentation, oxidation, and percolation ponds.

The recommended plan for the Gilroy-Morgan Hill wastewater treatment facilities is to continue geohydrological assessments to determine impacts of continued effluent disposal by percolation at the Gilroy site. If beneficial uses of surface and ground waters are not adequately protected, other treatment and/or disposal methods must be used. Disposal will continue to be by percolation, evaporation, and reclamation. Before a discharge to surface waters is considered, the City will be required to evaluate feasible land disposal options. If current percolation practices are not causing receiving water problems, feasibility of existing disposal area expansion should be considered. The Cities are also evaluating stream disposal. Currently, the Cities of Gilroy and Morgan Hill are responsible for collection, treatment, and disposal of wastewater. They are also responsible for operating the wastewater reclamation facilities. Santa Clara Valley Water District is responsible for

administrative tasks for the reclamation system. In addition, the Cities of Gilroy and Morgan Hill have implemented a pretreatment program since 1983.

Individual on-site systems are used for sewage disposal in the San Martin area. Twenty percent of the area's wells exceed the nitrate drinking water objective. This is a significant problem since this area serves as the sole recharge area for the Santa Clara Valley. Methods of providing a water supply that is free of excessive nitrate concentration should be investigated and implemented. Nitrate loadings from various sources should be calculated for the area to determine the contribution from various sources. The need for on-site system restrictions should be determined.

Small discharges (less than 0.10 mgd) in the Hollister area include flows from San Benito County Facilities, Sunnyslope County Water District, and Tres Pinos County Water District. City of Hollister wastewater is treated at the City of Hollister Wastewater Treatment Facilities (1.2 mgd). San Juan Bautista wastewater is treated at the City of San Juan Bautista Wastewater Treatment Facilities (0.15 mgd).

The recommended plan for Tres Pinos is to retain the existing evaporation/percolation ponds. The recommended plan for San Benito County Hospital Facilities and Sunnyslope County Water District is to study the feasibility of constructing interceptors to the Hollister facilities or consolidating into a single subregional system. Existing facilities consisting of aerated pond treatment followed by land disposal to evaporation/percolation ponds may be maintained if project level studies determine this to be the more feasible method of wastewater treatment and disposal. Sunnyslope County Water District owns and operates a wastewater treatment and disposal system serving approximately 300 homes in Ridgemark Estates subdivision located approximately 2-1/2 miles south-east of Hollister. Wastewater is treated in two aerated ponds and disposed of in evaporation/percolation ponds. Effluent may be used in the future to irrigate a golf course.

The recommended plan for the City of Hollister is to retain the existing advanced primary treatment facilities and percolation ponds which started operating in 1979. The Hollister industrial system is to be maintained separately to receive seasonal flows from the spinach and tomato processing operations. The recommended plan for the City of San Juan Bautista is development of a land disposal system. The City currently discharges secondary effluent to a drainage ditch tributary to Pajaro River.

Land disposal of wastewaters in the Hollister region must be monitored carefully to assure ground water quality is protected. Source control of salt must be stressed to reduce effluent salinity to levels acceptable for disposal to local ground waters.

Wastewaters in the Watsonville area are transported to regional treatment facilities in the City of Watsonville with a design capacity of 13.4 mgd. Collection, primary treatment, and disposal to Monterey Bay are provided for the City of Watsonville, and the local sewering entities of Freedom County Sanitation District, Pajaro County Sanitation District, and Salsipuedes Sanitary District. The City submitted an application to EPA for waiver of secondary treatment requirements and the Regional Board has approved a waiver permit. Project level studies determined ocean disposal to be the most feasible method of waste disposal. Ocean outfall improvements and a phased approach to secondary treatment are included in Watsonville's Clean Water Grant Project. If a waiver from secondary treatment is granted, the project will provide advanced primary treatment. Local sewering entities retain ownership and direct responsibility for wastewater collection and transport systems up to the point of discharge to interceptors owned and operated by Watsonville. The City is implementing a pretreatment program and the Regional Board has approved a waiver permit.

VI.B.3. CARMEL RIVER HYDROLOGIC UNIT

Summarized municipal dischargers in the Carmel River Hydrologic Unit include Carmel Sanitary District. Table 4-3 displays dischargers summarized for the Carmel River Hydrologic Unit.

Table 4-3. Carmel River Hydrologic Unit Summarized Municipal Dischargers

Carmel Sanitary District
Carmel Valley Sanitation District
Village Green
White Oaks
Carmel Valley Ranch
Carmel Highlands Inn
Carmel Sanitary Association

The Carmel Sanitary District operates a secondary wastewater treatment plant with ocean disposal serving Carmel-by-the-Sea, Del Monte Forest, and a few adjacent areas. The outfall system terminates within a portion of Carmel Bay that is designated an Area of Special Biological Significance (ASBS). The District is developing a reclamation project for irrigation of Monterey Peninsula Golf Courses. A high concentration of golf courses in a water short area makes reclamation particularly desirable and attractive.

Carmel Valley Sanitation District operates three facilities in Carmel Valley. These include community septic tank/subsurface disposal systems at Village Green and White Oaks and a tertiary type treatment plant with golf course reclamation at Carmel Valley Ranch. No changes are recommended unless public health or water quality problems develop. Should the need arise for specific septic system maintenance in Carmel Valley, local agencies should be considered for management responsibilities.

Comprehensive studies to determine the feasibility of establishing separate treatment plants have been completed for the Carmel Valley area. These studies conclude that on-site septic systems should remain operational until further ground water monitoring data shows sewers are necessary. Wastewater treatment and reuse on the Carmel Valley Ranch Golf Course provides an optimal way of managing waste generated in the area.

Carmel Highlands wastewaters should continue to be treated in on-site wastewater systems except at the Highlands Inn and the Carmel Highlands Sanitary Association. Both of these systems will continue to discharge treated secondary quality effluent to the Pacific Ocean.

VI.B.4. SANTA LUCIA HYDROLOGIC UNIT

The U.S. Navy's Point Sur wastewater facilities and the State Department of Parks and Recreation Pfeiffer Big Sur State Park facilities are the only significant facilities in this hydrologic unit. Ocean discharge from the U. S. Navy is being discontinued and is being replaced with a subsurface land disposal system. The subsurface land disposal system at Pfeiffer Big Sur State Park also seems adequate. If expansion to this facility is considered or if ground or surface water degradation from this discharge is detected, other means of disposal, such as reclamation, are recommended.

VI.B.5. SALINAS RIVER HYDROLOGIC UNIT

The extensive Salinas River Hydrologic Unit includes the Monterey Peninsula and southern coastal area of Monterey Bay, the City of Salinas, agricultural and small urban centers of the Salinas Valley, and recreational developments in the upper watersheds. Major dischargers in the Salinas River Hydrologic Unit include the Monterey Regional Water Pollution Agency (MRWPCA). Table 4-4 displays dischargers summarized below for the Salinas River Hydrologic Unit.

Table 4-4. Salinas River Hydrologic Unit Summarized Municipal Dischargers

Monterey Regional Water Pollution Control Agency (MRWPCA)
U.S. Army Fort Hunter Liggett
California Army National Guard - Camp Roberts
King City
City of Paso Robles
City of Atascadero
San Luis Obispo County Service Area No. 7A Oak Shores
San Luis Obispo County Service Area No. 19 Heritage Ranch Development

The recommended plan for the Monterey Peninsula-Salinas area calls for consolidation of

Monterey Peninsula, Salinas, Castroville, and other Monterey Bay municipal wastewater flows into a regional wastewater treatment plant and outfall. Discharge is to central Monterey Bay outside the prohibition zone described in Chapter 5 "Discharge Prohibitions" under "Waters Subject to Tidal Action." Upon completion of the regional plant, wastewater treatment plants in Monterey, Salinas (2), Castroville, and Fort Ord will be taken out of service. The Monterey Regional Water Pollution Control Agency (MRWPCA) was established to manage and implement regional consolidation.

It is recommended MRWPCA implement wastewater reclamation. MRWPCA plans to provide reclaimed water to the Castroville Irrigation Project which involves irrigating food crops in the Castroville area with water reclaimed at the regional plant blended with water diverted from the Salinas River.

New major residential developments proposed within the service area of the Regional Project should connect to the regional system unless studies can show that water quality and public health concerns can be properly mitigated. Sewerage feasibility studies and aerial ground water studies should continue in this sub-basin to assure that adequate sewage treatment and disposal capabilities are maintained for both existing and proposed development.

Recommended plans for Salinas Valley communities, the U. S. Army's Fort Hunter Liggett, the California Army National Guard's Camp Roberts, and recreational areas in the upper watershed involve separate wastewater treatment and disposal facilities.

Dischargers along the Salinas River should remain as separate treatment facilities with land disposal to evaporation/percolation systems and land application (irrigation) systems where possible. Disposal should be managed to provide maximum nitrogen reduction (e.g., through crop irrigation or wet and dry cycle percolation). Facility expansions shall include means for nitrogen reduction. Shallow ground water monitoring at these facilities will determine if additional improvements are necessary. King City should consider expanding its service area to include Pine Canyon if development continues in that area.

The City of Paso Robles owns and operates a secondary treatment plant (4.9 mgd) utilizing trickling filtration followed by oxidation ponds. Disposal is by evaporation and percolation from the oxidation ponds and by discharging from the last pond to the Salinas River channel. Use of reclaimed water should be investigated and implemented, if feasible. A reduction of inorganic salt in the effluent would increase its desirability to potential users. A report, "Water Quality in the Paso Robles Area," published by the California Department of Water Resources in 1981 made water quality control recommendations, including a recommendation for more stringent control of total dissolved solids and sodium in the City's wastewater treatment plant discharge. A Regional Board Salt Balance Study is planned to further define the need and methods of salt reduction.

The City of Paso Robles also owns and operates the wastewater facility serving the California Youth Authority and Paso Robles Airport Wastewater treatment plant (0.10 mgd). Disposal is to a series of oxidation-percolation ponds located adjacent to Huerhuero Creek. Wastewater reclamation uses should be investigated. An effluent pump exists at the plant in case wastewater reclamation potential develops. The City is planning an interceptor sewer to eliminate this facility and provide all treatment and disposal at its main City facility.

The City of Atascadero (1.67 mgd) owns and operates a wastewater collection, treatment, and disposal system serving part of the City. Pond treatment is provided followed by land disposal to percolation ponds and by irrigation of a golf course. San Luis Obispo County Health Department has documented public health problems and water quality problems arising from failing on-site sewage disposal systems in areas within the City. The City was sewered in the most significant problem areas, but additional sewering is needed.

Dischargers in the Nacimiento Reservoir area include San Luis Obispo County Service Area No. 7A, Oak Shores Development (0.1 mgd); and, San Luis Obispo County Service Area No. 19, Heritage Ranch Development (0.40 mgd). Wastewater facilities for the Oak Shores Development consist of two aerated treatment ponds and spray disposal. Part of the collection system is located below the spillway elevation of Nacimiento Reservoir. This has been a

source of excessive infiltration in the past and the problem has been corrected. This area should be watched closely as reservoir level rises and wastewater flows increase to insure infiltration and/or exfiltration do not reoccur. Major expansion of wastewater facilities is expected in the future. As the development grows, new disposal facilities should be relocated well away from Nacimiento Lake.

Wastewater at Heritage Ranch is treated in aerated lagoons at the development. Discharge is to a holding pond, filtered, and then discharged to a drainageway located outside the Nacimiento Reservoir watershed.

Camp Roberts is a U. S. Army installation that is leased by the California National Guard as a major training site. Wastewater flows that vary from 3000 gpd in winter to nearly 1.0 mgd in summer are treated to secondary levels prior to disposal in a series of percolation/evaporation ponds located near the Salinas River. The facility was upgraded in 1980 and there are no additional recommendations.

Dischargers in the San Antonio Reservoir watershed include Monterey County's Department of Parks and Recreation and the U.S. Army's Fort Hunter Liggett. There are no recommended changes to facilities operated by the Monterey County Department of Parks and Recreation. The U.S. Army, Fort Hunter Liggett operates wastewater treatment facilities located adjacent to the San Antonio River. The recommended plan is to maintain the existing facilities with improvement of the spray disposal area.

VI.B.6. ESTERO BAY HYDROLOGIC UNIT

Municipal wastewater management plans for the Estero Bay Hydrologic Unit are described for each of these four areas: North Coast, Morro Bay, San Luis Obispo Creek, and South County Regions. Table 4-5 displays dischargers summarized below.

Table 4-5. Estero Bay Hydrologic Unit Summarized Dischargers

Cambria Community Services District
San Simeon Acres Community Services District
City of Morro Bay and Cayucos Sanitary District
California Men's Colony
Los Osos septic tank/leachfield systems
City of San Luis Obispo
Avila Beach County Water District
San Luis Obispo County Service Area No. 18-Country Club Estates
City of Pismo Beach
South San Luis Obispo County Sanitation District
Lopez Recreation Area Wastewater Treatment Plant

Dischargers in the North San Luis Obispo Coast include Cambria Community Services District (1.0 mgd) and San Simeon Acres Community Services District (0.2 mgd).

Secondary treatment facilities at Cambria have a design capacity of 1.0 mgd and include a land outfall and spray irrigation system for effluent disposal, and an effluent holding reservoir. Excess effluent that cannot be spray-irrigated is pumped to the reservoir for later land disposal or discharged during wet weather through a sand filter bed to Van Gordon Creek. The District is evaluating land disposal improvements. Implementation of this plan is the responsibility of Cambria Community Services District.

San Simeon Acres Community Services District owns and operates a secondary treatment (activated sludge) plant with design capacity of 0.2 mgd. Wastewater visitor complex generated at Hearst Castle and within the community is treated and discharged to the Pacific Ocean through an ocean outfall. The recommended plan is to retain the treatment plant.

Dischargers in the Morro Bay area include the City of Morro Bay and Cayucos Sanitary District (2.1 mgd), California Men's Colony (CMC) (1.2 mgd), and Los Osos- Baywood septic tank leachfield systems.

The City of Morro Bay and the Cayucos Sanitary District jointly own treatment facilities with ocean outfall disposal. Wastewater is being treated by a newly constructed plant and discharged through a newly constructed ocean outfall. In order to

maximize plant capacity and meet Ocean Plan requirements, part of the effluent receives primary treatment only and part receives secondary treatment. Primary and secondary quality effluents are blended before disposal to the Pacific Ocean in compliance with a secondary treatment waiver.

Recently renovated wastewater treatment facilities at California Men's Colony also serve the California National Guard Camp, Cuesta College, the County Educational Center, and the County Operational Facility. Secondary treatment with coagulation/filtration, and subsequent disposal to Chorro Creek (stream flow augmentation) are provided. Effluent is also used to irrigate fodder crops on nearby lands owned by California State Polytechnic University.

Development on small lots in Los Osos-Baywood has resulted in one of the most densely populated areas without public sewers on the central coast. Septic tank effluent is discharged in predominantly sandy soil over a ground water basin which is the sole source of water for the area. Some shallow wells have approached and exceeded the public health maximum nitrate concentration limit. The County of San Luis Obispo conducted a Clean Water Grant funded study of this situation. Study findings resulted in a Basin Plan Prohibition of discharges effective November 1, 1988. The County has not implemented the recommended project of sewering the area. (A new septic system discharge prohibition now exists for the area).

Dischargers in the San Luis Obispo Creek area include the City of San Luis Obispo (5.1 mgd), Avila Beach County Water District (0.1 mgd), and San Luis Obispo County Service Area (CSA) No. 18, Country Club Estates (0.12 mgd).

The City of San Luis Obispo wastewater treatment facilities serve as a regional plant for the City and certain proximal unincorporated county areas. Trickling filters provide secondary treatment before disposal to San Luis Obispo Creek. Infiltration and inflow in the wastewater collection system causes excessive wet weather flows and intermittent discharges to San Luis Obispo Creek of partially treated wastewater. The recommended plan for San Luis Obispo is improving the collection and treatment facilities capacity to eliminate these discharges. The City's Wastewater Management Plan should be implemented to provide treatment necessary to comply with stringent permit requirements.

The small community of Avila Beach is served by a small advanced primary trickling filter wastewater treatment facility owned and operated by the Avila Beach County Water District. Design capacity of the plant was originally 0.18 mgd, but was downgraded in 1986 to 0.1 mgd as the NPDES permit was revised to include secondary treatment standards for tickling filters. Current average flow is only 0.07 mgd. Wastewater disposal is through an ocean outfall to the Pacific Ocean. Additional treatment and/or outfall modification will be necessary as flow increases. Oceanographic studies would be required to determine appropriate modifications (e.g., lengthen the outfall and add a multiport diffuser).

Country Club Estates (CSA No. 18) is a small subdivision in South San Luis Obispo County that historically relied on septic tank systems for wastewater treatment and disposal. A septic tank system performance survey completed in January, 1981, identified significant public health hazards from numerous failing septic tank systems in the subdivision. The septic systems were replaced in 1988 by a small secondary treatment plant (0.12 mgd) with effluent disposal via golf course irrigation at the San Luis Obispo Golf and Country Club.

Dischargers in the South San Luis Obispo County Region include the City of Pismo Beach (1.2 mgd), South San Luis Obispo County Sanitation District (3.0 mgd) (serving the City of Arroyo Grande, City of Grover City, and Ocean Community Services District), and Lopez Recreation Area wastewater treatment plant (0.10 mgd). These dischargers provide secondary treatment of wastewater through three separate facilities. Pismo Beach has a land outfall to the South San Luis Obispo County Sanitation District ocean outfall. Plant reliability improvements were made in 1987. Future treatment plant enlargements should provide duplicate process units for improved operation and maintenance. A long range solids management plan must be developed and implemented.

South San Luis Obispo County Sanitation District disposes of secondary effluent through an ocean outfall to the Pacific Ocean. The District has enlarged its facilities to 3.0 mgd and changed from activated sludge to fixed film reactor. A long range

solids management plan is also needed for this plant.

The Lopez Recreation Area treatment facilities serve County facilities adjacent to Lopez Lake. Lopez Lake serves as a municipal water supply for downstream coastal communities. It is recommended land disposal of wastes be continued. Ground water quality monitoring should be used to provide warning of any potential ground water problems downstream of the disposal area. Implementation of this plan is the responsibility of the County of San Luis Obispo.

VI.B.7. CARRIZO PLAIN HYDROLOGIC UNIT

There are no municipal sewerage systems in the Carrizo Plain Hydrologic Unit; recommended practices for individual disposal systems will pertain to this area.

VI.B.8. SANTA MARIA RIVER HYDROLOGIC UNIT

The municipal wastewater management plans for the Santa Maria Valley and the Cuyama Valley are described separately for the City of Guadalupe, the City of Santa Maria, the Laguna County Sanitation District, Nipomo, and the New Cuyama wastewater treatment plant.

It is recommended that separate wastewater treatment and disposal/reclamation facilities be maintained by the City of Guadalupe (0.5 mgd), the City of Santa Maria (7.8 mgd), and the Laguna County Sanitation District (3.2 mgd). Discharge will be to land in each case.

The City of Guadalupe provides primary treatment followed by mechanically aerated lagoons. An unincorporated neighborhood known as the Gularte Tract is located adjacent to Guadalupe. A lift station and interceptor have been constructed to transport Gularte's wastewater to the City's collection system.

The recommended plan for Guadalupe is to complete additional storage ponds and disposal facilities to insure containment of wastewaters during wet weather and accommodate planned growth and to continue effluent discharge to land. Use of reclaimed water to irrigate nearby pasture lands is encouraged and should be maximized. Implementation of this plan is the responsibility of the City of Guadalupe. The County of Santa Barbara will be responsible for wastewater collection and transport systems for Gularte Tract up to the point of discharge to interceptors owned and operated by Guadalupe.

The City of Santa Maria provides wastewater collection, treatment, and disposal services to the City of Santa Maria, Santa Maria Airport District, and part of Laguna County Sanitation District. Biological secondary treatment is provided with disposal to percolation ponds and irrigation lands. The recommended plan for Santa Maria is to retain the existing treatment and disposal facilities. Since the Santa Maria ground water basin is in a state of adverse dissolved solids balance, it is imperative that quantities of total dissolved solids, sodium, chloride, nitrogen, and nitrogen compounds be kept to a minimum by implementing a strict source control ordinance. Additional measures -- importing better quality water, drilling new wells, partial desalting, etc. - may be required in the future to provide a suitable water supply for the area. Laguna County Sanitation District retains ownership and direct responsibility for wastewater collection and transport systems up to the point of discharge into interceptors owned and operated by the City of Santa Maria.

A secondary wastewater treatment plant owned and operated by Laguna County Sanitation District treats most of the wastewater generated within the District. Wastewater is discharged to approximately 2,250 acres of private lands located adjacent to the facility. The landowners and the County have a 30-year agreement for irrigation of fodder, fiber, and seed crops. The recommended plan for Laguna is to improve plant performance and increase capacity through a staged construction plan. Enough land is available to allow expansion and continue reclamation. Recommended improvements include increasing capacity and reliability of the Orcutt Lift Station, increasing sludge drying bed area, and expanding effluent, pumping, storage, and conveyance facilities. Funding of future

improvements and plant expansions would be through connection and user charges. Laguna County Sanitation District is responsible for implementation of the recommended plan. Impact of salts must be minimized by implementing a strict source control ordinance and discharging to areas outside the main ground water recharge area.

Failing individual on-site sewage disposal systems in the community of Nipomo resulted in a treatment facility being completed in 1987. Treatment is by aerated lagoons and disposal is by percolation beds. Sewer service is provided to downtown Nipomo and County operated systems of Nipomo Palms, Black Lake Estates, and Galaxy Subdivisions. The recommended plan is to extend the sewer system to small lot areas as growth allows.

Existing facilities at the New Cuyama Wastewater Treatment Plant provide primary treatment of wastewater, with some aeration. Effluent is chlorinated before discharge to Salisbury Creek. The recommended plan for New Cuyama is to study existing facilities, determine future needs of the community, and, since water is in short supply, explore wastewater reclamation alternatives. Cuyama Community Services District is the responsible party for wastewater and water supply facilities in New Cuyama. It is recommended that exploratory wells be drilled to find a higher quality water supply. If a lower salt content water is not available, the existing water supply should be partially demineralized.

VI.B.9. SAN ANTONIO CREEK HYDROLOGIC UNIT

Los Alamos Community Services District owns and operates a wastewater treatment and disposal facility to serve the Los Alamos community. Wastewater (0.1 mgd) is treated in mechanically aerated ponds and discharged to disposal ponds and a spray reclamation area.

VI.B.10. SANTA YNEZ RIVER HYDROLOGIC UNIT

Municipal wastewater management plans for the Santa Ynez River Hydrologic Unit are described below. Table 4-6 displays dischargers discussed below.

Table 4-6. Santa Ynez River Hydrologic Unit Summarized Municipal Dischargers

City of Lompoc
Mission Hills Community Services District
Vandenberg Air Force Base
U. S. Department of Justice, Bureau of Prisons
Buellton Community Services District
City of Solvang
Cachuma County Sanitation District

Parts of Lompoc Valley ground water basin are in a state of adverse salt balance because of municipal and agricultural discharges. It is imperative that impacts of point source waste discharges to land be reduced by continuing to implement strict salt limitations, source control programs, and other salt management practices.

The City of Lompoc operates a secondary treatment facility (5.0 mgd) and discharges treated effluent to Santa Ynez River. The City also provides service to Vandenberg Village Community Services District and sewered areas of Vandenberg Air Force Base. The recommended plan for Lompoc is to control mineral concentrations in the effluent by enforcing strict limits on discharges to the sewer system and to continue to implement a pretreatment program. Implementation of this plan is the responsibility of the City of Lompoc. Vandenberg Air Force Base and Vandenberg Village Community Services District retain ownership and direct responsibility for wastewater collection and transport systems up to the point of discharge into the wastewater treatment plant and/ or interceptors owned and operated by the City of Lompoc.

In 1980, the Mission Hills Community Services District (0.4 mgd) was formed, assuming ownership and responsibility for water supply and sewage disposal in Mission Hills. The District expanded and

upgraded its La Purisima Plant and eliminated the Rucker Road Plant. Wastewater is treated in mechanically aerated ponds and discharged to a series of evaporation/percolation ponds and reclamation areas. Separate water reclamation requirements were adopted for Mission Belle Dairy as a primary user of reclaimed water for pasture and fodder crop irrigation.

There are isolated areas of Vandenberg Air Force Base that are not served by the Base's collection system. Separate treatment and disposal systems exist to serve these areas. Due to the isolation of these systems, it is recommended that they be retained. Efficient operation and maintenance of these systems will protect public health and water quality.

The United States Department of Justice, Bureau of Prisons, owns and operates existing facilities at the U.S. Penitentiary (0.6 mgd) which provide secondary treatment of wastewater. Treated wastewater is reclaimed for irrigation of forage crop land.

It is recommended that facilities be maintained separately at Buellton Community Services District (0.65 mgd), City of Solvang (1.0 mgd), and Cachuma County Sanitation District (0.22 mgd). Secondary treatment prior to land disposal coupled with a strict source control program will be necessary to protect local ground waters in these three areas.

The City of Solvang operates a secondary wastewater treatment facility to serve the City and Santa Ynez Community Services District with effluent disposal to evaporation/percolation ponds. Since the disposal ponds are located in a flood-prone area, it is imperative that sufficient disinfection capacity be available to disinfect effluent during wet weather. Expansion of capacity should be considered for ongoing growth in areas adjacent to present City and District boundaries. Implementation of this plan is the responsibility of both the City of Solvang and Santa Ynez Community Services District. Need for, and feasibility of providing, sewerage facilities for the Los Olivos-Ballard areas should be investigated by the County of Santa Barbara. Treatment and disposal service for this area be contracted with the City of Solvang.

The recommended plan for Cachuma County Sanitation District is to continue to treat and dispose of wastewater in percolation ponds and spray fields outside the Cachuma Reservoir watershed. Since ground waters down gradient from the spray field are used for domestic water supply, sampling of the nearest down gradient well is recommended to insure that water supply quality is not adversely affected by the discharge.

VI.B.11. SOUTH COAST HYDROLOGIC UNIT

Summarized municipal wastewater treatment and disposal agencies in the South Coast Hydrologic Unit are described separately for the Goleta Sanitary District (9.7 mgd), City of Santa Barbara (11.0 mgd), Montecito Sanitary District (1.5 mgd), Summerland Sanitary District (0.20 mgd), and, Carpinteria Sanitary District (2.0 mgd) wastewater treatment plants.

Goleta Sanitary District operates a wastewater collection system within the District and a treatment and ocean disposal system to provide service to Goleta Sanitary District, Isla Vista Sanitary District, University of California at Santa Barbara, Santa Barbara Municipal Airport, and facilities of Santa Barbara County. EPA granted the District a waiver from secondary treatment requirements. The waiver permit limits flow to 7.9 mgd provided mass emission rates do not exceed limits based on a flow of 7.3 mgd. In order to meet EPA's conditions and Ocean Plan criteria, part of the effluent receive primary treatment only and part receives secondary treatment. Primary and secondary effluent are blended before disposal to the Pacific Ocean. The District implements a pretreatment program. Isla Vista Sanitary District, University of California at Santa Barbara, Santa Barbara Municipal Airport, and Santa Barbara County retain ownership and direct responsibility for wastewater collection and transport systems up to the point of discharge into interceptors owned and operated by Goleta Sanitary District. A long range solids management plan is needed to assure sludge disposal needs are met.

The recommended plan for the City of Santa Barbara is to retain El Estero Wastewater Treatment Plant, with disposal to the Pacific Ocean, along with implementation of the City of Santa Barbara wastewater reclamation project. The City could consider implementing a cost-effective composting program to reduce transportation costs. The City implements a pretreatment program and also provides service to an unincorporated community in Mission Canyon located above the City.

The recommended plan for Montecito Sanitary District is to continue secondary treatment with disposal to the Pacific Ocean.

The recommended plan for Summerland Sanitary District is to expand and upgrade existing facilities to insure reliable plant operations and to accommodate planned growth. Recommended improvements are addition of standby power, dual processes, and continuous monitoring of total chlorine residual.

The recommended plan for Carpinteria Sanitary District is to retain existing secondary treatment facilities with disposal to the Pacific Ocean.

VI.C. INDUSTRIAL WASTEWATER MANAGEMENT

In general, the alternatives available to industrial discharges are the following: (1) ocean discharge and compliance with the State Ocean Plan, the State Thermal Plan, and Public Law 92-500; (2) containment of nonsaline and non-toxic wastes on land; (3) reinjection of oil and gas production brines; (4) inland surface water discharge, if other alternatives are proved infeasible; and, (5) abandonment of the treatment facility and connection to a publicly owned treatment works. In most cases, alternatives will be limited by standards of performance and pretreatment standards being developed by EPA. It should also be noted that federal guidelines will be subject to regional considerations such as important fishery resources or wildlife areas which could necessitate making regional industrial discharge requirements more stringent than national performance standards.

Specific effluent limitations are being promulgated for existing industrial waste discharges together with standards of performance and pretreatment standards of performance for new sources pursuant to sections 304(b), 306 (b), and 307(b), of the federal Water Pollution Control Act. Effluent limitations were being circulated for comment by the EPA. Waste source categories of particular interest in the basin which will be covered by those sections of the federal law include:

Meat product and rendering processing

Dairy product processing

Canned and preserved fruits and vegetables processing

Canned and preserved seafood processing

Cement Manufacturing

Feedlots

Electroplating

Beet sugar processing

Petroleum production and refining
Steam electric power plants

Leather tanning and finishing

Further information pertaining to industrial discharges can be found in the Management Principles and Control Actions Section of Chapter 5. The State Water Resources Control Board Plans and Policies Section, Discharge Prohibition Section, and Regional Board Policies Section are likely to apply (depending on site specific circumstances).

VI.D. SOLID WASTE MANAGEMENT

The protection and maintenance of water resources requires consideration and regulation of solid waste management practices. This section discusses present and future solid waste production, existing disposal practices and their effect on water quality, and proposed plans for solid waste disposal within the study area.

Land disposal is regulated by the California Code of Regulations, Title 23, Chapter 15 (Chapter 15). In the vernacular of Chapter 15, wastes are classified as either hazardous waste, designated waste, nonhazardous solid waste, or inert waste. Waste Management Units (WMUs) are classified as either Class I, II, or III depending on the type of waste to be disposed of in the unit. Class I WMUs have the most restrictive siting criteria and must be constructed to provide optimum conditions for isolation of wastes from waters of the State. A double liner and a leachate collection and removal system (LCRS) is required for all Class I units. Class II WMUs also have relatively restrictive siting and construction standards and are designed to totally isolate wastes from the environment. Double liners and LCRSs are typically, but not always, required for Class II units. Class III WMUs must be sited and constructed such that no impairment of beneficial uses of surface or ground water beneath or adjacent to the site occurs. Siting and construction standards for Class III units are the least restrictive of the three, but the requirements are still considerable.

Wastes are considered hazardous if they meet the criteria defined in CCR Title 22, Section 66300. Examples of wastes that are considered hazardous include: waste solvents, waste pesticides, and waste electroplating solutions, to name a few. Hazardous wastes must be discharged only at Class I WMU.

Wastes are classified as designated if, under ambient conditions at the WMU, they may be released in concentrations in excess of applicable water quality objectives or cause degradation of waters of the State. Some examples of designated waste include, wet sewage treatment plant sludge, oil field wastes, and some drilling muds. Designated wastes must be disposed of only at Class I WMU's, or at Class II WMU's which are approved for that particular type of waste.

Nonhazardous solid wastes consist of the more typical household and industrial wastes including: trash; rubbish; ashes; demolition and construction wastes; discarded home and industrial appliances; manure; and vegetable or animal solid or semi-solid wastes provided they do not meet the criteria mentioned above for hazardous or designated wastes. Nonhazardous solid waste may be disposed of at any classified WMU, but normally it is disposed of only at Class III WMUs to conserve the diminishing volume in the few operating Class I and Class II WMUs.

Inert waste does not contain hazardous waste or soluble pollutants at concentrations in excess of applicable water quality objectives and does not contain significant quantities of decomposable waste. Some examples of inert wastes include: broken up concrete rubble and excess clean earth fill. Inert wastes do not necessarily need to be disposed of at classified waste management units (i.e., Class I, II or III), but waste discharge requirements may be issued for the discharge at the discretion of the Regional Board.

There are 28 authorized active waste disposal sites regulated by the Central Coast Regional Board. Of the 28 sites, 26 are Class III landfills, with one Class I landfill, and one Class II surface impoundment. Additional information regarding a specific waste management unit can be found in the respective County Waste Management Plan in which the unit is located.

In recent years, data indicates municipal solid waste landfills may be having a greater impact on water resources than was previously anticipated. Legislation was passed in 1984 which requires all owners of active, inactive, or former landfills to initiate a study to determine if the landfilling operation has had an impact on waters of the State. Approximately 150 sites are evaluated per year throughout the State, with approximately nine sites per year coming from the Central Coastal Region. Further studies and/or corrective actions are initiated at all sites impacting State waters.

A recent report from the Assembly Office of Research has documented California's dwindling remaining landfill capacity. In general, remaining landfill capacity within the Central Coastal Region is higher than most areas of the State. However, the ratio of landfill closures to landfill expansions or opening of new landfills within the region for the last five years is approximately 4:1. This ratio will probably remain the same or increase with the more stringent regulatory requirements and the time consuming permitting process required for siting of new waste management units. In order to avoid a landfill capacity crisis similar to the situation on the East Coast, our solid waste handling and disposal practices should be reevaluated and a more environmentally sound management practice should be developed.

The Toxic Pits Cleanup Act of 1984 (TPCA) declares that discharges of liquid hazardous wastes or hazardous wastes containing free liquids into lined or unlined impoundments pose a serious threat to the quality of the waters of the State. Therefore, the legislature enacted TPCA as Article 9.5 (Surface Impoundments) of Chapter 6.5 (Hazardous Waste Control) of Division 20 of the California Health and Safety Code with the intent of insuring that existing surface impoundments were either made safe or were closed.

The effect of TPCA was to prohibit discharge (defined to include storage) of liquid hazardous wastes and hazardous wastes containing free liquids to surface impoundments, which did not satisfy specific construction and monitoring standards, by June 30, 1988, or December 31, 1988, depending on the location and characteristics of the impoundment. TPCA allows specific exemptions with varying application and granting deadlines. However, on and after January 1, 1989, all discharge of liquid hazardous wastes and of hazardous wastes containing free liquids to surface impoundments which had not been granted exemptions, and which did not meet specific construction and monitoring standards, was prohibited. There is a rare set of circumstances which may exempt a surface impoundment from the January 1, 1989, deadline.

TPCA is fulfilling its goal of reducing the threat of liquid hazardous wastes to the waters of the State.

VI.D.1. SOLID WASTE DISCHARGE PROHIBITIONS

Discharge is prohibited as follows:

1. Any Class I solid waste material to any location other than Class I solid waste disposal site.

2. Any Class II solid waste materials to any location other than Class I or II solid waste disposal sites.

3. Solid wastes shall not be discharged to rivers, streams, creeks, or any natural drainage ways or flood plains of the foregoing.

VI.E. STORM WATER MANAGEMENT

Storm water runoff can be a significant pollution source. The United States Environmental Protection Agency (U.S. EPA) estimates that at least 33% of all contamination in lakes and estuaries and 10% of all river contamination are caused by storm water runoff. Sources of pollution include runoff from industrial facilities, construction sites, and urban municipalities.

Federal regulations (40 Code of Federal Regulations 122.26) require certain industrial facility owners and/or operators to obtain storm water discharge permits. The specific types of facilities that need coverage is dependent upon the facility's Standard Industrial Classification Code. The program is primarily directed at manufacturing facilities, oil and gas extraction facilities, transportation maintenance facilities (trucking and mass transit), and construction sites (with greater than five acres of land disturbance). In addition, municipalities with populations greater than 100,000 must participate in a municipal storm water permitting program.

In August and September 1992, the State Water Resources Control Board (State Board) adopted the statewide General Construction Activity Storm Water

Permit and amended the statewide General Industrial Activities Storm Water Permit. The statewide permits expire five years after adoption. At that time, Regional Boards will most likely adopt Region specific General Permits.

The storm water program objectives include identification and elimination of pollutant contact with storm water by implementation of Best Management Practices. To obtain coverage under a General Permit, an applicant (i.e., those facilities required under 40 Code of Federal Regulations 122.26) must submit a Notice of Intent and the appropriate fee. The Notice of Intent is an agreement accepting the discharge specifications and monitoring requirements of the General Permit.

General Industrial Permit Requirements include the development of a Storm Water Pollution Prevention Plan and storm water runoff monitoring. The Storm Water Pollution Prevention Plan is a facility specific document which includes: a site description, facility processes, pollutant sources, storm water management system, employee education and training program, and measures proposed to eliminate non-storm water discharges. Minimum monitoring and reporting requirements include: sampling and analysis of four pollutant indicator parameters, wet and dry weather storm water conveyance system inspections, and annual reporting. The Regional Board can recommend additional monitoring parameters based on the presence of specific pollutant sources.

The Construction Permit has similar requirements regarding development of a storm water pollution prevention plan, but mainly deals with reducing pollutant sources associated with erosion and sediment transfer and chemicals used at construction sites. The monitoring requirements are less stringent and no sampling is required.

Annual monitoring reports required by the Industrial permit are due July 1 of each year. Sampling results and annual report information will be used to prioritize Regional Board staff education and enforcement efforts and to develop future group general permits. Compliance is measured through implementation of pollution prevention Best Management Practices, reduction in pollutant loadings, and accurate and timely report submittal.

VI.F. BAY PROTECTION AND TOXIC CLEANUP PROGRAM

The State Water Resources Control Board (State Board) established the Bay Protection and Toxic Cleanup Program in response to legislation enacted in 1989 (Chapter 269; Senate Bill 475 Torres) which added Chapter 5.6, Sections 13390 through 13396, to the California Porter-Cologne Water Quality Control Act. The Bay Protection and Toxic Cleanup Program is a statewide program that is coordinated with the California Department of Fish and Game and California Environmental Protection Agency's Office of Environmental Health Hazard Assessment. The Water Code requires the State and Regional Water Quality Control Boards to do the following to attain the goals of the Bay Protection and Toxic Cleanup Program:

1. Develop and maintain a program to identify toxic hot spots, plan for their cleanup or mitigation, and amend Water Quality Control Plans/Policies to abate toxic hot spots;

2. Formulate and adopt a Water Quality Control Plan for enclosed bays and estuaries;

3. Review and, if necessary, revise Waste Discharge Requirements to conform to the Plan;

4. Develop a database of toxic hot spots;

5. Develop an ongoing monitoring and surveillance program;

6. Develop sediment quality objectives;

7. Develop criteria for assessment and priority ranking of toxic hot spots; and

8. Fund the program through fees on point and nonpoint dischargers. (California Code of Regulations, Title 17, Section 2236, authorizes the fee program).

Funds for the Bay Protection and Toxic Cleanup Program will come from user fees, as proposed by State Board staff. User fees have been drafted for the following:

1. All NPDES and WDR dischargers to the ocean, bays, or estuaries;

2. Counties or cities which operate a storm drain system which discharges to the ocean, a bay, or estuary;

3. Dischargers of agricultural drainage to the ocean, bays, or estuaries;

4. Boat construction and repair facilities;

5. Boat marinas and recreational facilities;

6. Operators of commercial harbors and ports; and

7. Operators of dredging discharges.

The fees are based on threat to water quality, as defined by the Waste Discharge System (WDS) ranking system (threat to water quality and complexity criteria).

The Central Coast Regional Board has identified 17 potential toxic hot spots to be addressed under this program. These 17 sites are identified in the Appendix. An assessment/monitoring plan has been developed for potential toxic hot spots. Potential hot spots are ranked according to threat to beneficial uses. The assessment/monitoring plan includes the following:

1. Definition of the extent of degradation;

2. Analysis of existing point and nonpoint discharges in the area;

3. Identification of contaminant sources; and

4. Development of options for removing the threat to beneficial uses, including consideration of additional effluent limits on point and nonpoint discharges and actual cleanup.

VI.G. MILITARY INSTALLATIONS

Military installations throughout the country include some of the largest and most complex contamination problems. In 1987, President Reagan signed into law Executive Order No. 12580 directing all federal facilities to investigate and remediate areas of environmental contamination. As a result, the U.S. Department of Defense has assumed responsibility for investigation and remediation at military bases. Certain environmental restoration projects involving hazardous materials and wastes from past military activities are being addressed through what is known as the U.S. Department of Defense Program. Although U.S. Department of Defense has assumed environmental restoration responsibility, the Regional Board is an active oversight participant.

From its inception, the Regional Board has been involved with a variety of military installation activities. Since 1990, this Regional Board has been actively and extensively involved in U.S. Department of Defense Program investigations and remedial activities at numerous military facilities within its jurisdiction. Active military installations in the Region addressed by the U.S. Department of Defense Program (current as of 1993) include Fort Ord, Presidio of Monterey, Monterey Naval Post Graduate School, Fort Hunter Liggett, Camp Roberts, Estero Bay Defense Fuel Supply Point, and Vandenburg Air Force Base. Fort Ord is unique since it is a closing base and has been identified as a federal superfund site. Four formerly used defense sites in the Region undergoing U.S. Department of Defense remediation (as of 1993) include: Camp San Luis Obispo - California National Guard, Camp San Luis Obispo - San Luis Obispo County, Paso Robles Airport, and Santa Barbara Airport. Potentially additional military facilities can be added to the U.S. Department of Defense Program.

Program Background

Decades of intense military activities have generated significant quantities of hazardous waste. As a result of insufficient internal control, improper handling and disposal practices, and inadequate regulation, military installations are now considered one of the Nation's most significant environmental polluters. Pollution problems are exacerbated by the large base size, the complex and varying missions, as well as routine personnel changes and inconsistent regulation and control. Many bases are actually small to midsize,

totally contained communities providing complete services for base operations. Services vary from base to base, but range from aircraft, vehicle, or shop maintenance and repair facilities to laundry services, photo shops, gas stations, and other typical municipal services (e.g., utilities, streets, water supply, sewerage, and solid waste disposal).

Past waste disposal practices in both government and private industries were insufficient to protect public health and the environment. Environmental laws and regulation developed in the 1970s addressed many deficiencies, but federal operations, especially the military, remained inadequately addressed. The military was adamant that sovereign immunity protected them from State and local environmental regulation. Enforcement actions to force the military to comply with State and federal regulation were often protracted or disregarded. In 1976, U.S. Department of Defense developed its Installation-Restoration Program to help identify, investigate, and cleanup contamination from past operations. Due to funding and timing, Program activities were initiated at most military facilities in the early 1980s.

In 1980, the federal Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA), which is also referred to as "Superfund" was enacted to address cleanup of hazardous substance disposal and spill sites. The Superfund Amendments and Reauthorization Act was enacted in 1986 to enhance hazardous waste cleanup. The Superfund Amendments and Reauthorization Act, in part, mandated the Defense Environmental Restoration Program specifically to address cleanups at U.S. Department of Defense facilities. The Defense Environmental Restoration Program included an Inland Restoration Program as a component. To carry out required environmental restoration at its military facilities, U.S. Department of Defense established the Defense Environmental Restoration Account as the funding mechanism.

Executive Order No. 12580 was enacted in 1987 to intensify investigation and remediation of environmental problems. The Executive Order directed all federal agencies to ensure environmental restoration. To comply with this Executive Order, U.S. Department of Defense has assumed lead responsibility to cleanup military bases throughout the world. California has the largest number of active military bases covered by the military cleanup plan.

As a result of Executive Order No. 12580 and growing public awareness, U.S. Department of Defense is now actively pursuing environmental restoration at military facilities. U.S. Department of Defense has demonstrated its restoration sincerity by providing oversight reimbursement to the State. The Defense/State Memorandum of Agreement signed by U.S. Department of Defense and State of California officials, provides State oversight cost reimbursement to a maximum of one percent (1%) of the total cleanup cost. The Memorandum of Agreement requires preparation and administration of a cooperative agreement between the State and Corp of Engineers to verify funding and services for remedial responses. The Memorandum of Agreement lists specific sites for which the State will receive federal funding for its oversight and regulatory involvement. In California, Regional Boards and the Department of Toxic Substances Control share State regulatory responsibility and reimbursement dollars allocated to the U.S. Department of Defense Program.

To ensure proper regulatory compliance and environmental restoration, Executive Order No. 12580 requires all federal agencies to complete cleanup pursuant to "Superfund." This means cleanups at all military installations must comply with the stringent federal CERCLA requirements, whether or not the base is a listed Superfund site. The Act requires federal facilities which are placed on the Superfund National Priorities List by the U.S. Environmental Protection Agency (U.S. EPA), to conduct cleanup following the National Contingency Plan and U.S. EPA procedures and standards. In this Region, Fort Ord is the only currently listed U.S. Department of Defense Superfund National Priority List site.

In addition to following federal CERCLA requirements, Superfund National Priority List sites must be conducted pursuant to agreements called Federal Facility Agreements. These agreements are

between the federal agency owning the base (e.g., Department of the Army at Fort Ord) and the U.S. EPA. The agreements may include certain State agencies. The Fort Ord Federal Facility Agreement includes the Regional Board and Department of Toxic Substances Control as signatories.
By federal law non-Superfund military sites must cleanup hazardous waste releases pursuant to federal Comprehensive, Environmental Response, Compensation, and Liability Act requirements and to State laws. Federal non-Superfund facilities may enter into a State compliance agreement. Such an agreement is called a Federal Facility Site Remediation Agreement. At Vandenburg Air Force Base (a non-Superfund site), a Federal Facility Site Remediation Agreement was signed by the Department of the Air Force, the Regional Board, and Department of Toxic Substances Control in June 1991. Both Federal Facility Agreements and Federal Facility Site Remediation Agreements identify roles, responsibilities, dispute resolution procedures, and schedules.

By signing an agreement (Federal Facility Agreement and Federal Facility Site Remediation Agreement), and following federal CERCLA requirements, site remediation is modified from typical State procedures. The modification eliminates the need for State and local permits and enforcement action. Generally, Waste Discharge Requirements, Cleanup of Abatement Orders, and local agency permits are not imposed. Such provisions were included to ensure compliance with stringent federal cleanup standards, while limiting permit and enforcement involvement by local or State Agencies. In some parts of the Country, local and State involvement slowed or obstructed cleanup efforts.

The federal CERCLA (Section 121) does require compliance with State and federal laws and regulations which are more stringent than the CERCLA, and which are necessary to ensure site-specific environmental and public health protection. This compliance process is referred to as "Applicable" or "Relevant and Appropriate" requirements, because it allows consideration of either "Applicable" or "Relevant and Appropriate" requirements pursuant to State or federal law and regulations. At Superfund sites, U.S. EPA has final authority to approve "Applicable" or "Relevant and Appropriate" requirements. At non-Superfund sites, the lead State agency is responsible to ensure "Applicable" or "Relevant and Appropriate" requirements are identified.

Federal Comprehensive, Environmental Response, Compensation, and Liability Act (Superfund) Response Process

Although cleanup pursuant to the federal CERCLA is quite complex, it was developed with the intent of simplifying regulatory requirements in a uniform manner and expediting environmental cleanup and restoration. The Act, although similar, is significantly more complex than the Regional Board's typical cleanup procedures pursuant to the California Porter-Cologne Water Quality Control Act. Following is a very simplified summary of the basic "Superfund" response process.

Many initial past military installation investigations included a Preliminary Assessment/Site Inspection. The Preliminary Assessment is an assessment based on existing, readily available information. The Preliminary Assessment attempts to evaluate the magnitude of a potential hazard and identify the source and nature of hazard release. The Site Inspection includes a site visit and possibly sample collection, soil borings, and well installation. The Site Inspection is intended to better characterize the problem and determine the need for further action. Often, information from the Preliminary Assessment/Site Inspection is used to place a site on the Superfund list.

Once a site has been Superfund listed, or has been identified as requiring remedial activities, more in-depth characterization is required. The next phase of remedial activities-site characterization is called the Remedial Investigation/Feasibility Study. The Remedial Investigation is the mechanism for collecting detailed site data to define fully the nature and extent of contamination. During the Remedial Investigation, treatability studies may be conducted to evaluate available treatment technologies in support of remedy selection. The Feasibility Study focuses on developing and screening specific remedial alternatives. The Feasibility Study goal is to identify preferred cleanup alternatives. The Remedial Investigation/Feasibility Study includes risk assessment, identifies "Applicable" or "Relevant and Appropriate" requirements, and develops cleanup goals.

The next phase is the Proposed Plan, which presents the preferred cleanup alternatives and allows public input. After public comments are considered, a Record of Decision is prepared at Superfund sites. The Record of Decision establishes cleanup levels and discharge standards and is based, in part, on identified "Applicable" or "Relevant and Appropriate" requirements. When the Record of Decision is complete and acceptable, the selected remedy is administratively approved by the military department, U.S. EPA, and the State (Regional Boards and Department of Toxic Substances Control). The final cleanup levels are established and "frozen" in the Record of Decision. Agencies that signed the Federal Facility Agreements also sign the Final Record of Decision. At non-Superfund sites in California, the typical document establishing the cleanup levels and discharge standards is called the Remedial Action Plan. The Remedial Action Plan is signed by the agencies that signed the Federal Facility Site Remediation Agreement. Decision Documents are used sometimes to identify cleanup levels for individual sites at non-Superfund installations. Agencies and the public can petition U.S. EPA to change the Record of Decision levels (or the State to change the Remedial Action Plan), if substantial evidence is available demonstrating that an established cleanup level is not protective of human health and the environment.

Once the Record of Decision (or Remedial Action Plan) is signed, Remedial Design plans are prepared to implement the Record of Decision. Remedial Action, the long-term remediation, begins when Remedial Design and construction are complete. Operation and maintenance, including monitoring, evaluate long term performance and ensure that the Remedial Action is carried out as intended. Long term remediation (e.g., ground water cleanup) continues until conditions of the Record of Decision (or Remedial Action Plan) have been met. Remediation progress must be evaluated at least every five years.

The federal CERCLA includes the Removal Action process to allow remediation of small/limited areas of contamination or time critical cleanups. A Removal Action may be undertaken at any time to address problems that do not require a full scale remediation project. Removal Actions are short term activities that remove immediate threats to public health or that can be implemented in a timely manner. Generally, Removal Actions are limited to $2 million and are completed in twelve months or less (e.g., removal and proper disposal of a small volume of surface soil contamination).

It is worthy to note that environmental assessment is addressed during the Remedial Investigation/Feasibility Study process. All military installations must comply with the National Environmental Policy Act by preparing an Environmental Impact Statement or Finding of No Significant Impact. An Environmental Impact Statement is similar to an Environmental Impact Report and a Finding of No Significant Impact is similar to a Negative Declaration in California. In California, National Environmental Policy Act compliance may not be sufficient to address all environmental impacts; thus, environmental assessment must also comply with the California Environmental Quality Act.

Regional Board Responsibility

The federal Clean Water Act and the California Porter-Cologne Water Quality Control Act give the Regional Board regulatory responsibility and authority to protect water quality, including waters within and beneath federal lands. The primary role of the Regional Board and its staff, relative to military installations (U.S. Department of Defense Program) is to ensure that waters of the State are adequately protected. Involvement includes review and direction of all investigation and remediation documents, site visits to guide field activities, and oversight to ensure that cleanup/remediation is carried out properly to protect beneficial uses of water resources. Identification of "Applicable" or "Relevant and Appropriate" requirements and direction on cleanup level establishment require considerable involvement by the Regional Board and its staff.

Typically, the U.S. EPA is the lead regulatory agency at Superfund sites (e.g., Fort Ord). The Regional Board and Department of Toxic Substances Control are responsible State agencies. In the past, at non-Superfund sites (all other military installations in the Region) either the Regional Board or Department of Toxic Substances Control has been the lead regulatory agency. At military installations where water quality and public health is threatened or impacted due to the release of hazardous

substances, the Regional Board and Department of Toxic Substances Control may have overlapping jurisdiction. A Memorandum of Understanding exists between the State Water Resources Control Board, the Regional Boards, and Department of Toxic Substances Control specifying roles and responsibilities in hazardous waste cleanups where overlap may occur. In September 1993, the California Environmental Protection Agency requested the overall State "lead" become Department of Toxic Substance Control's responsibility. This transition should not impact the basic responsibilities. In general, Regional Boards have primary regulatory responsibility for water and soils directly related to water quality protection. Department of Toxic Substances Control has primary regulatory responsibility for public health protection, soil (where waters are not involved), air, and hazardous waste treatment and storage.

In this Region, the Regional Board has been the lead State agency at six of the currently active (1993) U.S. Department of Defense facilities (Vandenberg Air Force Base, Estero Bay Defense Fuel Supply Point, Camp Roberts, Fort Hunter Liggett, Monterey Naval Post-Graduate School, and Presidio of Monterey). These sites are shown in Figure 4-1. The lead may be shared with Department of Toxic Substances Control at Fort Hunter Liggett, since there are several federal Resource Conservation and Recovery Act sites requiring investigation. In California, U.S. EPA has authorized Department of Toxic Substances Control to implement
Resource Conservation and Recovery Act program compliance.

Agreements have been signed only at Fort Ord and Vandenberg Air Force Base in this Region. The Federal Facility Agreements for Fort Ord identifies the Regional Board as a support agency since the U.S. EPA is the lead regulatory agency. The current Federal Facility Site Remediation Agreement identifies the Regional Board as the lead agency at Vandenberg Air Force Base. Agreements could be negotiated at other military installations, or re-negotiated when they currently exist, if and when it becomes necessary to clarify roles and responsibilities. Changes are being considered in California to streamline regulatory processes associated with military installation cleanup, particularly at closing bases. The California Environmental Protection Agency has recently designated (September 1993) Department of Toxic Substances Control as the overall State lead at military installations. This designation will impact program activities, roles, and responsibilities.

VI.H. SPILLS, LEAKS, INVESTIGATIONS AND CLEANUP PROGRAM

The Spills, Leaks, Investigations, and Cleanup program was established to allow Regional Boards to address water quality problems and potential problems resulting from discharges not covered by other State programs. Investigations and cleanups of Spills, Leaks, Investigations, and Cleanup program sites proceed as described in State Board Resolution No. 92-49 explained in the "Hazardous Waste Compliance Issues" section later in this chapter.

Spill, Leak, and Complaint Responses

Regional Board staff responds to complaints of nuisance conditions (e.g., odors from sewage treatment plants) and discharges or threatened discharges of substances which may impact ground and/or surface water quality. Complaints are followed up as soon as feasible. Proper response to a complaint includes the following:

- Completion of a Central Coast Region spill report form.
- Notification to other responsible agencies, or interested parties, as needed.

Figure 4-1. Active Military Installations in the Central Coast Region

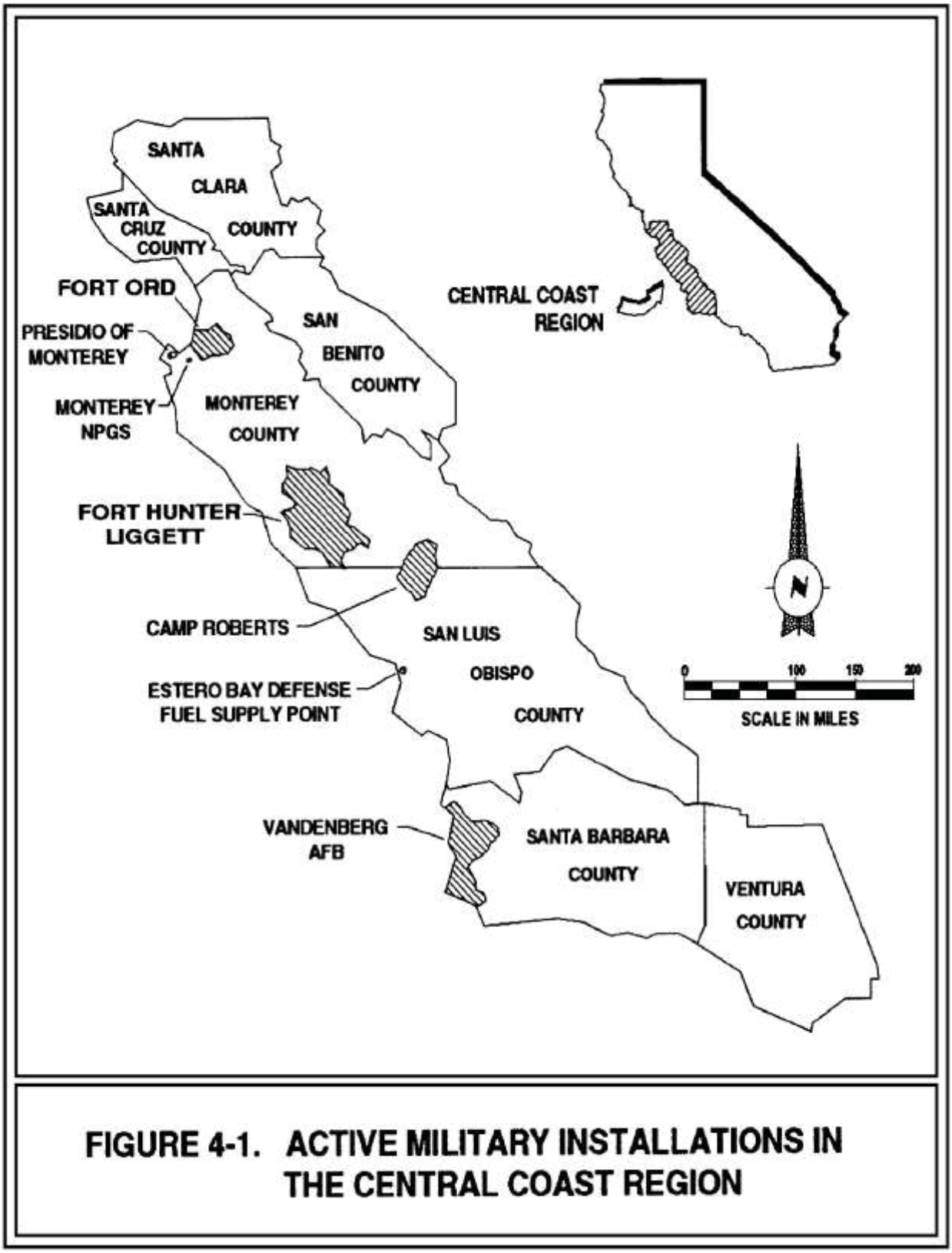

FIGURE 4-1. ACTIVE MILITARY INSTALLATIONS IN THE CENTRAL COAST REGION

- Site inspection to determine validity of the complaint and to assess the situation, including determination of responsible party/parties.

- Written follow-up as needed (letters, cleanup or abatement orders, and/or waste discharge requirements)

- Except in cases where anonymity is requested, notification to complainant of findings and subsequent actions, if any.

Except for a discharge in compliance with waste discharge requirements, any person who causes or permits any reportable quantity of hazardous substance or sewage to be discharged in or on any waters of the State, or discharged or deposited where it is or probably will be discharged into or on any waters of the State, shall, as soon as possible, notify the Office of Emergency Services of the discharge in accordance with the spill reporting provision of the State toxic disaster contingency plan. The person shall also immediately notify the State Board or the appropriate Regional Board of the discharge (California Porter-Cologne Water Quality Control Act Section 13271).

Similarly any person who discharges any oil or petroleum product under the above stated conditions shall, as soon as possible, notify the Office of Emergency Services of the discharge in accordance with the spill reporting provision of the State oil spill contingency plan. Immediate notification of an appropriate agency of the federal government, or of the appropriate Regional Board (in accordance with the reporting requirements set under California Porter- Cologne Water Quality Control Act Section 13267 or 13383) shall satisfy the oil spill notification requirements of this paragraph (California Porter-Cologne Water Quality Control Act Section 13272).

The Regional Board staff will assist other agencies and work cooperatively at large-scale hazardous material releases resulting from surface transportation accidents. The Regional Board staff's role is primarily to provide immediate, on-site technical assistance concerning water quality in order to minimize the potential damage to the public health and safety, and the environment. In cases of railroad incidents, Regional Board staff will work with other agencies pursuant to the Office of Emergency Services Railroad Accident Prevention and Immediate Deployment Plan. Specifically, Regional Board staff are required to:

- Provide information on existing downstream beneficial uses and potential impacts from released substances.

- Provide toxicity information about released substances.

- Set up water sediment monitoring program.

- Collect water samples or provide technical assistance for others to collect samples.

- Coordinate available resources and equipment.

VI.I. UNDERGROUND STORAGE TANK PROGRAM

In 1981, citizens of Santa Clara County determined the cause of numerous birth defects to be polluted ground water. The source of pollution was traced to underground storage tanks leaking chlorinated solvents. This revelation prompted the San Francisco Bay Regional Water Quality Control Board to investigate numerous other underground storage tanks, the majority of which were found to be leaking. The Santa Clara County Fire Chiefs Association then sponsored a task force which developed, in 1982, a Model Hazardous Material Storage Permit Ordinance. The Ordinance addressed materials regulated, secondary containment, permits, inspections, and so forth.

Recognizing the problem was a statewide problem, the Legislature passed the initial State underground storage tank law in 1983, and numerous counties and cities followed with local ordinances to regulate underground storage of hazardous materials. The State law contains a sunset provision with a termination date of January 1, 1998.

Since 1985, over 21,000 leaking tank sites have been reported statewide and over 1250 have been reported within the Central Coast Region. Of the reported cases, approximately 90% are petroleum

product cases and one-third have impacted ground water. As one might expect, Regions with the larger cities (thus more gasoline stations) have the largest number of reported leaks. The same holds true in the Central Coast Region. Santa Barbara County has almost fifty percent of the cases in this Region (up from 37% a few years ago) and San Benito County has only four percent; Monterey County has about twenty percent.

The Health and Safety Code gives both Regional Boards and local agencies authority to oversee investigation and cleanup of leaky Underground Petroleum Storage Tank sites. The California Code of Regulations, Title 23, Chapter 16, Article 11 requires local agencies to oversee leak reporting and tank closures. Two agencies within the Central Coast Region, Santa Clara and Santa Barbara Counties, also provide oversight for cleanup of leaky Tank sites under a Local Oversight Program contract with the State Board.

Unauthorized releases from underground tanks are reported to the Regional Board by local agencies or private parties. Generally, investigation and cleanup of leaky Underground Petroleum Storage Tank sites is shared between the Regional Board and local agencies. Typically the Regional Board oversees cases involving impact to surface and ground water and local agencies oversee impacts to soil. However, in some circumstances the Regional Board oversees both soil and ground water cleanup, and, in Santa Barbara and Santa Clara Counties, Local Oversight Programs oversee both soil and ground water cleanup.

Investigations and cleanup of leaky Tanks are carried out in a manner similar to investigations and cleanups in the Spills, Leaks, Investigations, and Cleanup Program mentioned earlier.

To assist responsible parties to pay for cleanups and to meet federal financial responsibility requirements, the State has established a Tank Cleanup Fund. Money for the fund is generated by a fee paid for each gallon of petroleum delivered to Tanks. Owners and operators of Tanks may draw upon the fund after paying for the initial $10,000 in cleanup costs. The Fund will pay up to $990,000 per cleanup.

Underground Petroleum Storage Tank regulations regarding construction, monitoring, repair, release reporting, and corrective action are found in the California Code of Regulations, Title 23, Division 3, Chapter 16. Regulations regarding the State's Underground Petroleum Storage Tank Cleanup fund are found in California Code of Regulations, Title 23, Division 3, Chapter 18, and regulations regarding underground testers are found in California Code of Regulations Title 23, Division 3, Chapter 17.

VI.J. ABOVEGROUND PETROLEUM STORAGE TANKS

Above ground petroleum storage tanks and associated piping leaks have been found to cause impacts to surface and ground water. Prior to 1990, above ground tank sites were regulated by the United States "Environmental Protection Agency Regulations on Oil Pollution Prevention", 40 Code of Federal Regulations Section 112, as amended. On January 1, 1990, the Above Ground Petroleum Storage Act became effective as Chapter 6.67 (commencing with Section 25270), Division 20, of the Health and Safety Code and amendment to Section 3106 of the Public Resources Code. The regulations require:

- Regional Boards to inspect above ground storage tanks used for crude oil and its fractions;
- Owners or operators of tank facilities to prepare and initiate a spill prevention control and countermeasure plan in accordance with Part 112, Subchapter D, Chapter I, Title 40 of the Code of Federal Regulations by January 1, 1991 and any required monitoring program within 180 days later;
- Tank facility owners or operators to report releases of crude oil and its fractions in excess of one barrel; and
- Owners or operators of tank facilities to submit a storage statement and appropriate filing fee every two years.

- The Above Ground Petroleum Storage Act provides for recovery of cost incurred by Regional Board staff for oversight of above ground tank site cleanups.

VI.K. CALIFORNIA CODE OF REGULATIONS, TITLE 23, CHAPTER 15

The California Code of Regulations, Title 23, Chapter 15 (Chapter 15) contains minimum, prescriptive standards for proper management of applicable wastes. Landfills, surface impoundments, septage and sludge disposal, mining operations, confined animal facilities, and some oil field exploration and production facilities are regulated according to Chapter 15. Regional Boards may impose more stringent requirements to accommodate regional and/or site-specific conditions. Factors affecting site specific considerations include: depth to ground water, permeability of underlying soils, geologic structure, importance of underlying ground water uses, waste characteristics, ability to remediate leaks, adequacy of the monitoring system, proximity of beneficial uses such as aquatic life, and others.

Dischargers may propose engineering alternatives to the construction or prescriptive standards contained in Chapter 15 if they can show the prescriptive standard is not feasible (i.e., too difficult or costly to implement, or not likely to perform adequately under the given circumstances). The proposed alternative must be able to provide equivalent management of the waste, and must not be less stringent than the prescribed standards.

Discharges to land which may be exempt from Chapter 15 are listed in the Basin Plan Waiver Policy in Chapter Five.

Wastes fall into four categories under the current classification system. These four categories are: Hazardous, Designated, Non-Hazardous, and Inert, and are defined in Article 2 of Chapter 15. Hazardous and Designated wastes can often be generated by the same source and may differ only by their concentrations of given constituents.

Wastes must be disposed of differently depending on their liquids content and the waste category into which they fall. A table containing the Summary of Waste Management Strategies for Discharge of Waste to Land is provided in the appendix.

Receiving water monitoring is required at all waste management units. Article 5 discusses the monitoring requirements for the various classes of waste management units, and describes the progressive phases of monitoring.

The routine ground water monitoring conducted during the entire compliance period of a project's life is referred to as "detection monitoring". If a release (leak) is detected during the course of detection monitoring, an "evaluation monitoring" program must be established. If the evaluation monitoring verifies the presence of a leak, a decision must be made as to whether the release represents a significant enough threat to water quality and the environment to warrant corrective action. If the leak is a significant water quality threat, a "corrective action program" must be established, including monitoring of the effectiveness of corrective action, and conducted until the problem has been successfully corrected.

Vadose zone monitoring must be conducted at all waste management units where feasible. Article 5 discusses the minimum requirements for an acceptable vadose zone monitoring program.

Special requirements for confined animal facilities are discussed in Article 6 of Chapter 15 and in Chapter 5 of this Basin Plan. These facilities are also subject to other portions of Chapter 15 as applicable.

Under Chapter 15, mining waste discharges are only subject to the requirements of Article 7, or other portions of Chapter 15 as referenced by Article 7. (Mining wastes are also subject to regulation under the Surface Mining and Reclamation Act, Public Resources Code Title 14, Division 2, Chapter 9).

Discharges of hazardous and nonhazardous waste, and the waste management units at which the wastes are discharged (e.g., landfills, surface impoundments), are regulated by the Regional Board through Waste Discharge Requirements to properly contain the wastes, and to ensure effective monitoring is undertaken to protect water resources

of the Region. These waste discharges are also concurrently regulated by other State and local agencies. Local agencies implement the State's solid waste management programs as well as local ordinances governing the siting, design, and operation of solid waste disposal facilities (usually landfills) with the concurrence of the California Integrated Waste Management Board.

The California Integrated Waste Management Board also has direct responsibility for review and approval of plans for closure and post-closure maintenance of solid waste landfills. The Department of Toxic Substance Control issues permits for all hazardous waste management, treatment, storage, and disposal facilities. The State Board, Regional Boards, California Integrated Waste Management Board, and Department of Toxic Substances Control have entered into Memorandums of Understanding to coordinate their respective roles in the concurrent regulation of these discharges.

The laws and regulations governing both hazardous and nonhazardous solid waste disposal have been revised and strengthened in recent years.

An inactive waste management unit can still pose a threat to water quality. In fact, due to the nature of some wastes and the characteristics of some disposal sites, sometimes water quality problems do not become evident until years after a site has closed. Therefore, Chapter 15 requires all waste management units have a plan for acceptable closure procedures and post-closure maintenance and monitoring.

VI.K.1. SOLID AND LIQUID WASTE REQUIREMENTS (LANDFILLS AND SURFACE IMPOUNDMENTS)

Solid wastes are usually disposed of in a landfill or Solid Waste Disposal Site. A landfill, as defined in Chapter 15, is a waste management unit at which waste is discharged in or on land for disposal. A landfill may be classified as Class I, II, or III, depending on the type of waste being accepted, but the term "landfill" typically refers to a Class III municipal solid waste landfill which accepts only inert or non-hazardous, municipal solid waste. Class I units are for hazardous wastes, Class II units are for designated wastes, and Class III landfills are for nonhazardous wastes as defined in Chapter 15, Article 3. Landfills are an integral component of many communities in the Central Coast Region. Hazardous and/or designated solid wastes must be disposed of in Class I or II landfills or waste piles, respectively, also referred to as Resource Conservation and Recovery Act or non-Resource Conservation and Recovery Act solid waste management units.

Liquid wastes may not be disposed of to Class III waste management units. Rather, liquid wastes must be discharged to Class I or II surface impoundments, depending on the waste classification.

Discharges from solid and liquid waste management units can impact both ground and surface waters. The receiving water most likely to be at risk from a waste management unit is the ground water beneath the site. Precipitation or runoff may enter the unit and contact the waste, percolate through it, and travel to ground water, carrying constituents of the waste with it to the vadose zone or ground water beneath the unit. Solid waste may contain enough free liquids to form a leachate which can migrate to ground water. Vapors may migrate from a waste management unit into the soils and ground water below the unit. Gases forming in a closed waste management unit may pressurize the unit and force contaminants into the ground water. A liquid waste impoundment may leak its content into the soils and ground water beneath the unit. Liquids may exit a waste management unit and travel to nearby surface waters. Uncontained solid waste may also be transported to surface waters by wind.

The Regional Board regulates all the active waste management units and some of the closed units in the Region under Waste Discharge Requirements which contain pertinent Chapter 15 regulations. Some of the applicable requirements include:

1. Waste management units must be sited in locations where they will not extend over a known Holocene fault, other areas of rapid geologic change or into areas with inadequate separation from ground water.

2. Waste management units must be constructed to minimize (Class III) or prevent (Class I and II) the possibility of leachate contacting ground water. The probability of accomplishing this goal may be improved by siting the unit in an area where the depth to ground water is very great or where natural geologic features will provide containment. A Class III waste management unit is required to have a composite clay and synthetic liner with a leachate collection and removal system, in accordance with federal Subtitle D requirements. New Class I and II units must also be lined. A discharger may propose engineered alternatives to the Chapter 15 and Subtitle D containment requirements, but the alternatives must provide equal or greater protection to the receiving waters at the site, per Article One.

3. To minimize or prevent the formation of leachate, solid waste management units shall be covered periodically (typically daily) with soil or other approved materials. The importance of effective interim cover is illustrated by recent improvements to some landfill interim covers which resulted in an apparent cessation of ground water degradation. Rainwater surface flow from offsite should be prevented from entering a waste management unit and contacting the wastes in the unit.

4. The potential receiving waters shall be monitored. A waste management unit shall have sufficient ground water monitoring wells at appropriate locations and depths to yield ground water samples from the uppermost water bearing strata with continued saturation at depth, to provide the best assurance of the earliest possible detection of a release from the waste management unit. Perched ground water zones shall also be monitored. Background monitoring should be conducted for at least one year prior to opening a new waste management unit.

   Chapter 15 requires vadose zone monitoring at all new sites and at any existing site, unless it can be shown to the satisfaction of the Regional Board no vadose zone monitoring devices would work at the site, or that installation of vadose zone monitoring devices would require unreasonable dismantling or relocating of permanent structures.

5. All operating waste management units must have an approved closure/post-closure monitoring and maintenance plan and their operators must provide the Regional Board with assurance sufficient funds are irrevocably committed to ensure the site will be properly reclaimed and maintained.

6. The operator of a waste management unit must obtain and maintain assurances of financial responsibility for known and foreseeable releases from the unit.

VI.K.2. WASTEWATER SLUDGE/SEPTAGE MANAGEMENT

Wastewater sludge (biosolids) is a by-product of wastewater treatment. Treated domestic sludge is now referred to as biosolids to encourage using this material for fertilizer and soil amendment. Raw sludge usually contains 93 to 99.5 percent water with the balance being solids present in the wastewater and added to or cultured by wastewater treatment processes. Most Publically Owned Treatment Works treat the sludge prior to ultimate use or disposal. Normally, this treatment consists of dewatering and/or digestion.

Treated and untreated sludges may contain high concentrations of heavy metals, organic pollutants, pathogens, and nitrates. Improper storage and disposal of municipal sludges on land can result in degradation of ground and surface water. Therefore, sludge handling and disposal must be regulated.

Septage and grease are usually considered liquid waste, so landfill disposal is usually restricted. Septage, the residual solids periodically pumped from septic tanks, is commonly applied to farm land as fertilizer. Grease waste is usually recycled, but grease trap pumpings are commonly rejected by grease recyclers. Grease and septage usually must be disposed in a Class I or II waste management unit.

The Regional Board will regulate disposal of sludge and septage pursuant to Chapter 15 and Department

of Health Services standards for sludge management.

Sludge containing less than 50% solids by weight may be placed in a Class III landfill (see section on Chapter 15) if it can meet the following requirements, otherwise it must be placed in a Class II surface impoundment:

1. The landfill is equipped with a leachate collection and removal system;

2. The sludge must contain at least 20 percent solids if primary sludge, or at least 15 percent solids if secondary sludge, mixtures of primary and secondary sludges, or water treatment sludge; and

3. A minimum solids-to-liquid ratio of 5:1 by weight must be maintained to ensure that the co-disposal will not exceed the initial moisture-holding capacity of the nonhazardous solid waste. The Regional Board may require that a more stringent solids-to-liquid ratio be maintained, based on site-specific conditions.

4. Non-hazardous sludge containing greater than 50% solids by weight is generally considered solid waste.

Beneficial reuse of sludge/septage is increasing in popularity. Sludges and septage, (including composted, liquid, dewatered and dried sludges) have been successfully used as a soil amendment/fertilizer on farmland, orchards, forest lands, pasture, land reclamation projects (e.g., strip mines and landfills), parks and home gardens. As the concentrations of heavy metals has dropped in municipal sludge, and as advanced sludge treatment methods are utilized, the public's acceptance of beneficial reuse projects has improved. However, improper land application of sludge/septage can cause significant odor nuisance, attract flies, contain high levels of pathogens and heavy metals, and be aesthetically offensive due to the presence of plastics.

Currently, regulation of sludge and septage management projects is under the jurisdiction of the Regional Board. Handling and disposal of sludge/septage can be regulated under Chapter 15 of Title 23, California Code of Regulations and California Department of Toxic Substance Control Standards for hazardous waste management. If sludge is used beneficially, the project may be exempted from Chapter 15, but the Regional Board may issue waste discharge requirements.

The U.S. Environmental Protection Agency (U.S. EPA) has promulgated a policy of promoting those municipal sludge management practices that provide for the beneficial use of sludge and septage while maintaining or improving environmental quality and protecting public health. On February 19, 1993, the U.S. EPA published final sewage sludge regulations in 40 Code of Federal Regulations 503. The 503 regulations are intended to assure that use and disposal of sewage sludges and septage comply with federal sludge use and disposal criteria developed by the U.S. EPA. The State Board or the California Integrated Waste Management Board may develop a State sludge management program consistent with the U.S. EPA's policy and criteria for land application, surface disposal, and incineration of sludge to seek federal authorization to implement the 40 Code of Federal Regulations 503 sludge regulations.

VI.K.3. MINING ACTIVITIES (NONFUEL COMMODITIES)

The Central Coast has had a rich and varied mining history. Currently extracted products include asbestos, decomposed granite, diatomite, dimension stone, dolomite, gypsum, limestone, sand and gravel, shale, specialty sand and stone. The hundreds of inactive metal mines and prospects appear to be the worst polluters though. Mercury, used partly to amalgamate gold ore, was mined from the Little Bonanza deposit, San Luis Obispo County, as early as 1862. The Buena Vista Mine, which ceased production in 1970 or 1971, is believed to have been the last mercury producer in the Central Coast Region. Chromite deposits have been mined in San Luis Obispo County since about 1870. By 1944, and probably until the demise of production possibly 20 years ago, San Luis Obispo County produced more chromite than any other California county. Other products mined or prospected for historically include gold, silver, manganese,

magnesium, antimony, copper, nickel, iron, barite, coal, feldspar, gemstones, biotite, molybdenum, peat, phosphate, sodium sulfate, sulfur, titanium, uranium, zircon, and possibly platinum.

The extent of environmental degradation by all mining ventures is not yet known. Active operations are regulated individually pursuant to the California Code of Regulations, Chapter 15, the Porter-Cologne Water Quality Control Act, the California Surface Mining and Reclamation Act and/or the federal Clean Water Act (including the NPDES permit program). About 25 active mines currently hold Waste Discharge Requirements and/or NPDES surface water discharge permits and a few operations have been granted waivers. Chapter 15 land disposal requirements are imposed as required.

Inactive operations with responsible parties fall under the same purview, as warranted. Inactive mines, with or without responsible parties (those without are considered abandoned) may be remediated as federal Superfund sites pursuant to federal Comprehensive, Environmental Response, Compensation, and Liability Act, or as State Board Cleanup and Abatement Account sites. Low interest loans or government or academic grants may, in rare cases, be applied to inactive mine remediation.

Mines are subject to the Resource Conservation and Recovery Act, although comprehensive regulations have not yet been written. If hazardous constituents are present, Resource Conservation and Recovery Act, Subtitle C, and California Code of Regulations Title 22 may apply to active and inactive sites.

VI.K.4. OTHER INDUSTRIAL ACTIVITIES

Cement Industry -- Concrete manufacturing operations generate two significant types of solid waste, kiln dust and "off-specification" concrete. The first, kiln dust, is classified as a designated waste under Title 22 and is typically disposed of in Class II or III landfills operated by the concrete manufacturers. The second waste, "off-spec" concrete, is generated in much greater quantities and, while classified as a hazardous waste due to its very high pH (often ranging from 12.5 to 13.5 pH units), is frequently dumped on-site at the concrete plants and spread.

Cement batch plants generate large quantities of liquid and semi-solid wastes from rinsing of cement trucks and/or cement covered equipment. This waste, referred to as "washout" is very alkaline (pH may be as high as 12.5 in fresh cement), is high in total dissolved solids, and may contain assorted heavy metals. Washout may also contain various air-entrainment additives or other chemicals.

The Regional Board regulates cement kiln dust disposal and all ready mix cement plants where water quality could be impacted. Wastewater from cement batch plants is considered to be a designated waste, and may need to be discharged to a lined impoundment, if site-specific characteristics (e.g., soil type, depth to ground water, ground water quality, etc.) will not protect ground water from degradation. The Regional Board will consider, on a case-by-case basis, the need to line cement wastewater ponds. Solid or semi-solid wastes should be deposited in landfills or other legal points of disposal unless the discharger can demonstrate the waste will not pose a threat to water quality if deposited onsite.

Asphalt production -- Asphalt batch plants generally involve mixing heavy long chain hydrocarbons with aggregates. Occasionally other hydrocarbon sources (diesel and gasoline contaminated soil) are mixed with asphalt as a beneficial reuse. Diesel fuel and other solvents are used to clean equipment and as "lubricants" to prevent asphalt from sticking to equipment. Large quantities of these materials are generally stored on-site. Water quality can be significantly degraded if these materials reach water courses. Waste control measures are fairly straightforward at such sites. Petroleum products should be stored in tanks, and the tanks placed in lined holding areas. If spillage to soil occurs, contaminated soils should be scraped up, stored on a liner, and incorporated into asphalt as soon as possible. A berm (or other runoff control) should be placed down gradient from earthen material stockpiles.

Oil Field Exploration and Production Facilities -- Oil exploration and production is a thriving business in the Central Coast Region. Although drilling muds

are exempt from Resource Conservation and Recovery Act, Oil Exploration and Production Operations are often subject to the requirements of Chapter 15 because they represent a threat to water quality. Due to the significant Chapter 15 workload, remote oil operations may not reach the top of the regulatory priority list. The Interstate Oil and Gas Compact Commission recently recommended:

"The review team recommends State Board obtain the resources necessary to fully discharge its responsibilities...seek adequate resources from the legislature or use some other mechanism to enable Regional Boards to process applications for WDRs in a timely manner...One option is to remove or raise the statutory cap on discharger fees so that State Board may restructure its fee system to improve its equity and cure substantial resource shortcomings."

The Interstate Oil and Gas Compact Commission also commended the Central Coast Regional Board for having a road spreading policy. This policy, Resolutions No. 73-05 and 89-04, is located in the appendix.

VI.L. RESOURCE CONSERVATION RECOVERY ACT (SUBTITLE D)

Policy for Regulation of Discharges of Municipal Solid Waste

On June 17, 1993, the State Water Resources Control Board (State Board) adopted Resolution 93-62, entitled Policy For Regulations Of Discharges Of Municipal Solid Waste. A copy of this policy is available in the appendix.

The Policy implements the State Board's regulations governing the discharge of waste to land, California Code of Regulations, Title 23, Chapter 15 (23 California Code of Regulations Section 2510 et seq., "Chapter 15"), and implements those water quality related portions of the federal regulations governing the discharge of municipal solid waste at landfills (40 Code of Federal Regulations Section 258.1 et seq., "federal municipal solid waste regulations") that are not addressed by Chapter 15. The federal municipal solid waste regulations apply to all landfills that receive waste on or after October 9, 1991; the majority of the federal provisions become effective on October 9, 1993 (federal deadline).

The Policy directs Regional Boards to revise-or adopt, as appropriate-prior to the Federal Deadline, the waste discharge requirements (WDRs) for each landfill subject to the federal municipal solid waste regulations. The revised WDRs must implement those regulations in the manner described in the Policy and must implement the Chapter 15 regulations as well.

Landfills are subject to Subtitle D in California beginning October 9, 1993 or October 9, 1995 depending on landfill size and whether it is within one mile of a drinking water intake.

These federal regulations apply to municipal solid waste landfills (Class III landfills, under Chapter 15). The Subtitle D regulations outline the classification of municipal landfills, siting criteria, design criteria, operation procedures, water quality monitoring parameters and standards, closure and post-closure care requirements, and financial assurance guidelines similar to Chapter 15. U.S. EPA considers Subtitle D to be minimum standards for landfill operation. States may have equal or more stringent requirements, but may not have less stringent requirements. If a state's landfill regulation program meets U.S. EPA's approval, that state may apply to become an U.S. EPA "approved state" for landfill regulation.

California received Subtitle D approval in October 1993 and will be able to consider engineering alternatives to certain provisions of Subtitle D.

VI.M. SOLID WASTE WATER QUALITY ASSESSMENT TEST

In 1984, California Porter-Cologne Water Quality Control Act Section 13273 was adopted to require operators (and/or owners) of active and inactive solid waste disposal sites to perform a Solid Waste Assessment Test investigation. About 150 sites per year are to be analyzed statewide. The State Board has approved a statewide ranked list including 2,242 sites in 15 ranks. It has prioritized all sites on the basis of the potential threat to water quality and has established schedules for Investigation Workplan (Workplan) and Solid Waste Assessment Test report's submittals. The Central Coast Region's 15 ranks include 131 sites. Test reports are due the first day of July each year, depending on their ranking. Rank One sites were due July 1, 1987.

If monitoring information conclusively demonstrates hazardous waste is migrating, or has migrated to State waters, the site owner/operator may request a waiver of the Test reporting requirements pursuant to Water Code Section 13273(c). Waiver requests are usually requested within 120 days of the notification date. Water Code Section 13273.1 allows the site operator to request an exemption from Test reporting requirements by submitting a Solid Waste Assessment Questionnaire. Questionnaires may be submitted if a site contains less than 50,000 cubic yards of waste and is not known nor suspected of containing hazardous substances, other than household hazardous wastes. Based on this Questionnaire, the Regional Board may exempt the Operator from all or part of the Solid Waste Assessment reporting requirements.

Solid Waste Assessment Test reports are required to contain:

1. An analysis of the surface and ground water on, under, and within one mile of the solid waste disposal site to provide a reliable indication whether there is any leakage of hazardous waste.

2. A chemical characterization of the soil-pore liquid in those areas which are likely to be affected if the solid waste disposal site is leaking, as compared to geologically similar areas near the solid waste disposal site which have been affected by leakage or waste discharge (Porter-Cologne §13273[b]).

3. A finding whether hazardous waste is leaching into surface or ground water on, under, and within one mile of the disposal site.

If hazardous waste has migrated, the Regional Board must notify the Department of Health Services and the Integrated Waste Management Board, and take appropriate remedial action (Porter-Cologne §13273[e]).

More than eighty percent of Test sites (mostly unlined) evaluated in all climates and geologic terrain in California have been found to impact ground water quality as part of the Solid Waste Assessment Test program.

From the beginning, the Test program was supported by the California General Fund. In recent years, agencies with programs with such funding have been under increasing pressure to find alternative funding or face elimination. These pressures resulted in the Test Program being understaffed and, in the summer of 1991, eliminated. At that time, almost 200 Test Reports had been accepted and reviewed by the Regional Water Boards. However, a backlog of nearly 300 additional Test Reports had been submitted and had not been reviewed. The Central Coast Region had reviewed and accepted 29 reports, however 14 were backlogged.

In 1992, the Legislature adopted Assembly Bill 3348 (Eastin) which allocated $2,500,000 from the Integrated Waste Management Board's "Solid Waste Disposal Site Cleanup and Maintenance Account" to the State and Regional Boards to fund the review of the above backlog. This law restricted these funds to the review of Solid Waste Assessment Reports from Ranks One through Five only and required the work be in accordance with a Memorandum of Understanding between the Regional Boards and the California Integrated Waste Management Board. This Memorandum of Understanding was signed by the Executive Directors of the two agencies in January 1993.

VII. HAZARDOUS WASTE COMPLIANCE ISSUES

The Regional Board obtains information regarding hazardous waste discharge through two reporting programs. These programs are "Reportable Qualities of Hazardous Waste and Sewage Discharges" and the "Proposition 65" program. These mechanisms are discussed below:

VII.A. REPORTABLE QUANTITIES OF HAZARDOUS WASTE AND SEWAGE DISCHARGES

California Porter-Cologne Water Quality Control Act Section 13271 requires the State Board and the Department of Health Services to adopt regulations establishing reportable quantities for substances listed as hazardous wastes or hazardous materials pursuant to Section 25140 of the Health and Safety Code. Reportable quantities are those which should be reported because they may pose a risk to public health or the environment if discharged to ground or surface water.

Similarly, the State Board was required to adopt regulations establishing reportable quantities for sewage. These requirements for reporting the discharge of sewage and hazardous materials do not supersede waste discharge requirements or water quality objectives.

The regulations for reportable quantities adopted by the State Board are included in Subchapter 9.2 of the California Code of Regulations.

VII.B. PROPOSITION 65

The Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) went into effect January 1, 1987. Proposition 65 is found in the Health and Safety Code, Section 25249.5, et seq. It prohibits discharges of chemicals known to the State to cause cancer or reproductive toxicity to a potential source of drinking water, with certain exceptions. The Governor is required to publish a list of such chemicals. The list must be updated yearly. The current list is found in 22 California Code of Regulations, Section 12000.

Section 25180 of the Health and Safety Code requires designated governmental employees to disclose information to the local Board of Supervisors and local health officer regarding an illegal discharge of hazardous waste if the discharge is likely to cause substantial injury to the public. A designated employee is one who is required to sign a conflict of interest statement. Any designated employee who knowingly or intentionally fails to report information, as required by Proposition 65, is subject to fines and imprisonment (Section 25180.7). The following information should be reported:

- Discharge type
- How discharge was discovered
- Location of discharge
- Probable discharger
- Possible contacts
- Concentration of contaminant in soil and/or water.

VIII. NONPOINT SOURCE MEASURES

The State Nonpoint Source Management Plan initiated development of specific program objectives to be implemented at the State and Regional level. Currently, Regional Board staff are implementing the following State Board program objectives:

A. Control of Nonpoint Source pollution (urban runoff; agriculture; land disturbance activities such as road construction/maintenance, land construction, timber harvesting, and mining; hydrologic modification; and individual disposal systems). These activities include outreach, education, public participation, technical assistance, financial assistance, interagency coordination, demonstration projects, and regulatory activities such as imposing septic tank area prohibitions.

B. Preparation of contracts for projects selected for grant funding. Regional Board staff also participate in these projects by providing technical assistance and publicizing their results.

C. Implementation of the 1990 Coastal Zone Act Reauthorization Amendments, as developed by the State Board and the California Coastal Commission. This shall be an enforceable Nonpoint Source Management Program to control land use and anthropomorphic activities impacts that have a significant affect on coastal waters. (Further discussion of the Amendments is provided later.)

D. Initiation of nonpoint source watershed pilot programs.

Using State program objectives, Regional Board staff developed task-specific workplans to address nonpoint sources of pollution. For the Central Coastal Region, the following tasks are managed and implemented by the Nonpoint Source Program staff:

Task 1: Water Quality Assessment

Regional Board staff reviewed and updated the nonpoint source portion of the Water Quality Assessment and prepared water body fact sheets. (The Water Quality Assessment and water body fact sheets are discussed in Chapter Six.)

Task 2: Watershed Studies/Planning

Three impaired watersheds (Morro Bay Watershed, San Luis Obispo Creek Watershed, and San Lorenzo River Watershed) have been targeted for intensive activity. Major activities for San Luis Obispo Creek watershed include:

1. Develop a Demonstration "Total Maximum Daily Load" model.

2. Create a "San Luis Obispo Creek Riparian Task Force".

3. Implement a riparian corridor restoration project.

4. Identify major nonpoint pollutants and sources.

5. Develop a watershed management program.

For Morro Bay watershed, the activities include:

1. Develop a long term monitoring program to assess water quality improvements associated with the implementation of nonpoint source pollution control measures.

2. Develop funding for the long term monitoring program.

3. Implement a sediment reduction program using best management practices.

4. Participate in the Morro Bay Task Force.

For San Lorenzo River watershed, the activities include:

1. Develop a detailed assessment of Nonpoint Source impacts in the watershed.

2. Develop a wastewater management plan for on/off-site wastewater disposal.

3. Develop of a nutrient objective for the river.

4. Conduct experimental on-site wastewater treatment to reduce nitrogen discharge into the environment.

Task 3: Outreach Program

Staff meets regularly with individuals and local government agencies to promote education and solutions on Nonpoint Source problems. Additionally, the use of grant and loan resources to correct Nonpoint Source problems is emphasized during outreach activities.

Specific outreach activities include participation on the San Luis Obispo Creek Riparian Task Force, Morro Bay Task Force, and various 319(h)/205(j)/Basin Planning Technical Advisory Committees, and development of grant applications with local agencies.

Task 4: Project Tracking and Participation

Regional Board staff prepare contracts, coordinate with project proponents, track project progress, review and approve invoices, and provide technical support for Nonpoint Source grant funded projects.

VIII.A. COASTAL ZONE ACT REAUTHORIZATION AMENDMENTS

In November 1990, Congress enacted Section 6217 of the Coastal Zone Act Reauthorization Amendments to help address the problem of nonpoint source pollution in coastal waters. Section 6217 requires that coastal states with federally approved coastal management programs develop Coastal Nonpoint Pollution Control Programs. The legislative history indicates that the central purpose of section 6217 is to strengthen the links between federal and State coastal zone management and water quality programs in order to enhance efforts to manage land use activities that degrade coastal beneficial uses. The State coastal zone management agency designated under Section 306 of the Amendments and nonpoint source management agency designated under section 319 of the Clean Water Act will have a dual and co-equal role and responsibility in developing and implementing the coastal nonpoint program.

The program gives the U.S. Environmental Protection Agency (U.S. EPA) and the National Oceanic and Atmospheric Administration joint authority to approve programs developed by the State to address 6217 requirements.

The State agencies chosen to develop California's Coastal Nonpoint Pollution Control Program are the State Board and the Coastal Commission. The statute requires that the State program be "coordinated closely with State and local water quality plans and programs." This means that the State's nonpoint source programs under Sections 208 and 319 of the Clean Water Act and the coastal program must be examined to determine if they comprehensively address land use activities and anthropomorphic effects that have a significant effect on coastal waters. In addition, the State agencies are charged with developing a coordinated program that:

- identifies categories of nonpoint sources that adversely impact coastal waters;
- describes management measures to be implemented;
- identifies the land uses and critical coastal areas that will require more stringent or additional management measures;
- describes the State-developed additional management measures to be implemented in critical areas;
- documents the authorities the State will use to implement both the guidance and additional management measures, including designation of a lead agency for each source category and/or subcategory; and
- sets forth a schedule to achieve full implementation of the guidance management measures within three years of program approval by U.S. EPA and National Oceanic and

Atmospheric Administration, and full implementation of additional management measures within six years of program approval.

The Coastal Commission and the State Board staff have been working on a strategy to develop the required Coastal Nonpoint Pollution Control Program plan. Recently, the State Board directed staff to review and revise the statewide Nonpoint Source Management Plan to include a strong coastal component. Revision of the Plan is intended to satisfy the requirements of Section 6217 within the existing framework of current nonpoint source activities.

On a Regional Board level, staff has been involved with the statewide program since 1991. A pilot project, "The New Coastal Nonpoint Pollution Control Program using the Morro Bay Watershed as a Model" was performed to assess the feasibility of establishing the Coastal Nonpoint Pollution Control Program in California. Regional Board staff supplied technical information and reviewed reports. Concerted planning and implementation efforts on target coastal watersheds such as Morro Bay will be major accomplishments to satisfy Coastal Nonpoint Pollution Control Program requirements. As the program goes statewide, Regional Board staff will attend technical advisory committee meetings and will work closely with staff of the State Board and other Regional Boards, as well as staff of other relevant local, State, and federal agencies to develop a workable Coastal Nonpoint Pollution Control Program.

Wastewater originating from nonpoint sources includes those from urban runoff, agricultural activities, on-site sewage disposal systems, and land disturbance activities. Management of these types of nonpoint source discharges are discussed in the following section. The Regional Board will be developing management practices for marinas and recreational boating; hydromodification facilities; and wetlands, riparian areas, and vegetated treatment systems at a future date.

VIII.B. URBAN RUNOFF MANAGEMENT

The effect of urban runoff on receiving water quality is a problem which has only recently come to be recognized. Most of the work up to the present has centered on characterizing urban runoff: concentrations of various constituents have been measured, attempts to relate these to such factors as land use type and rainfall intensity have been made, and studies concerning the amounts of these constituents present on street surfaces have been conducted. It appears that considerable quantities of contaminants, heavy metals in particular, may enter the receiving waters through urban runoff. The federal Water Pollution Control Act Amendments of 1972 stress future "control of treatment of all point and nonpoint sources of pollution." Thus the federal government has concluded that nonpoint sources, such as urban runoff, are indeed deleterious to the aquatic environment and that measures should be taken to control such emissions.

There are four basic approaches to controlling pollution from urban runoff: (1) prevent contaminants from reaching urban land surfaces, (2) improve street cleaning and cleaning of other areas where contaminants may be present, (3) treat runoff prior to discharge to receiving waters, and (4) control land use and development. Which approach or combination of approaches is most effective or economical has not yet been studied extensively. Thus only the basic characteristics of each approach can be discussed. In addition to these direct approaches, measures to reduce the volume of runoff from urban areas are also available.

VIII.B.1. SOURCE CONTROLS

The first approach, which emphasizes source control, has many aspects. Tough effective air pollution laws can probably aid in reducing the amount of certain materials deposited on the land. An obvious example is lead in automobile exhaust emissions. Effective anti-litter ordinances and

campaigns can aid in reducing floatable materials washed to surface waters. These materials are objectionable primarily from an aesthetics viewpoint, although water fowl can be affected by plastics. New construction techniques may reduce emissions to receiving waters. Erosion can be decreased by seeding, sodding, or matting excavated areas as quickly as practicable. Construction in certain critical areas can be limited to the dry season. Stockpiling of excavated material can be regulated to minimize erosion. Control of chlorinated hydrocarbon pesticide usage would reduce the amounts found on urban land surfaces and thus reduce the amounts washed to natural waters.

VIII.B.2. STREET CLEANING

The second approach to reducing pollution from urban runoff involves improving street cleaning techniques. Generally, street cleaning as presently practiced is intended to remove large pieces of litter which are aesthetically objectionable. The removal of fine material which may account for most of the important contaminants is minimal. It may be possible to design mechanical sweepers to remove a greater fraction of the fine material. Alternatively, vacuum-type street cleaners could produce better results.

In addition to streets, sidewalks and roofs contribute large amounts of runoff. Controlling contaminants present on these surfaces would be more difficult and would be up to individuals. Advertising campaigns would probably be unproductive and legislation would be unworkable except perhaps in specific, localized situations. Therefore, contaminant removal will probably be limited to street surfaces.

In many areas, streets are cleaned by flushing with water from a tank truck. If catch basins are present, this material may be trapped in them. If catch basins do not exist, the material will be simply washed to the storm sewers where subsequent rainfall will carry them to surface waters. Where catch basins are regularly cleaned out, they can be effective in removing materials during runoff. Where they are allowed to fill up with material, they add to the pollution loading during a storm by discharging septic material. In any case, catch basins usually exist in older urban areas and have a rather low efficiency in removing contaminants from storm water.

VIII.B.3. TREATMENT

The third approach to reducing the effects of urban runoff on receiving water quality involves collecting and treating the runoff. Physical or physical-chemical treatment would be required; the intermittent nature of storm flows precludes biological treatment. Examples of possible treatment processes are simple sedimentation, sedimentation with chemical clarification, and dissolved air flotation. In addition to cost, a principal problem with this approach is collection. Present storm sewerage systems generally drain to open creeks and rivers or directly to tidal waters. Even if treatment facilities were located at various sites in the Basin, a massive collection system would have to be built.

The economic question of "treatment vs. transport" would have to be studied with specific regard to storm water runoff. Local sewage treatment plants abandoned in favor of regional facilities could possibly be utilized in such a program. One method of cutting down the peak flow capacity required is to provide storage volume in the collection system.

Solutions to the problem of preventing water quality degradation by urban runoff are only in the earliest stages of development and consist mostly of plausible hypothesis on how to deal with the problem. Therefore, it is not possible at this time to present a definite plan with regard to this subject. It is probable that research and study which up to now has emphasized defining and characterizing the problem, will turn to developing methods of control. The federal Water Pollution Control Act Amendments of 1972 state specifically that the EPA is authorized to conduct and assist studies "which will demonstrate a new or improved method of preventing, reducing, and eliminating the discharge into any waters of pollutants from sewers which carry storm water..." Considerable progress will be made during the next few years.

Information should be collected and studied so that a workable plan can be implemented in the future.

VIII.B.4. CONTROL OF URBANIZATION

A fourth approach is to encourage controls on urbanization which will either reduce the volume of runoff or at least not cause runoff to increase as a result of urban growth. The usual pattern is that increased urbanization leads to higher runoff coefficients, reflecting the many impervious surfaces associated with development. Roof drains to storm sewers, paved parking lots and streets, installation of storm sewers, filling of natural recharge areas, and increased efficiency in realigned and resurfaced stream channels all are characteristics of urban growth. Development near streams and on steep slopes is deleterious to water resources; it is less disruptive to develop the lower portions of a watershed than the headwater areas, both from the standpoint of the length of channel affected and the extent of channel enlargement necessary to convey storm water. Use of porous pavements and less reliance on roof connections to storm drains and more emphasis on local recharge would reduce the peak volume of runoff from storms. Areal mass emissions of urban drainage constituents should be quantified. Urban planning should be more cognizant of land constraints to permit greater natural recharge where possible and feasible and to discourage intensive development of steep land particularly in headwater areas.

VIII.C. AGRICULTURAL WATER AND WASTEWATER MANAGEMENT

Agricultural wastewaters and the effect of agricultural operations are a result of land use practices; controls should ultimately be developed from land use plans. Controls are required to minimize adverse effects from agricultural practices. The following discussion is confined to recommended improvements in practices and to the scope of federal-state permit programs which will regulate certain agricultural activities. The discussion of practices is limited here to animal confinement and irrigation practices. Although Public Law 92-500 defines a confined animal operation as a point source, this plan presents it in the traditional manner of dispersed nonpoint sources. Pesticide use and limits on fertilizer applications are not specifically considered; these materials are covered by appropriate water quality objectives.

VIII.C.1. FEDERAL-STATE PERMITS GOVERNING AGRICULTURAL OPERATIONS

Dischargers of wastes are managed in part by the NPDES permit program. Any person proposing to discharge waste that could affect the quality of the waters of the State must file a report of waste discharge with the appropriate regional board. The Regional Board will prescribe discharge requirements. The requirements implement water quality control plans and take into consideration beneficial uses to be protected.

Public Law 92-500 directed the Environmental Protection Agency to set up a permit system for all dischargers. Agriculture is specifically considered and permits are required for:

1. Feed lots with 1,000 or more slaughter steers and heifers.

2. Dairies with 700 head or more, including milkers, pregnant heifers, and dry mature cows, but not calves.

3. Swine facilities with 2,500 or more swine weighing 55 pounds or more.

4. Sheep feedlots with 10,000 head or more.

5. Turkey lots with 55,000 birds, unless the facilities are covered and dry.

6. Laying hens and broilers, with continuous flow watering, and 100,000 or more birds.

7. Laying hens and broilers, with liquid manure handling systems, and 30,000 or more birds.

8. Irrigation return flow from 3,000 or more continuous acres of land when conveyed to navigable waters from one or more point sources.

The law also provides that the State may administer its own permit program if EPA determines such program is adequate to carry out the objective of the Law. On March 26, 1973, this authority was transferred from the EPA to the State of California for waters within the State. Thus, the Regional Board issues discharge requirements to the agricultural operations covered under the aforementioned guidelines. The State may require discharge permits from any discharger, regardless of size.

VIII.C.2. ANIMAL CONFINEMENT OPERATIONS

Animal confinements such as feedlots and dairy corrals present a surface runoff problem during wet winter flows. Runoff water passes through hillside operations to sometimes contribute manure loads to the surface streams. Stockpiled manure may also add to the problem. Disposing of washwater and manures from dairies in such a manner that ground waters are not degraded can be a problem. Most dairies have some associated land for waste disposal. The land is devoted to crops and pasture and its assimilative capacity will depend upon the size, crop, crop yield, and the season. During intensive growth periods, crops can utilize more nutrients than in slow growth period. Small dairies with adequate crop land in close proximity may be able to use washwaters year round as a source of nutrients. Large dairies with smaller acreage will view the slurry wastes as a disposal problem, not a resource. Thus, there theoretically exists a threshold size for waste disposal. Regulations to achieve this size would be impractical and unenforceable. Crop land is expensive in the basin and would be difficult to acquire. However, a combination of crop patterns and pasture land best suited for each size operation should be determined and the dairymen should be encouraged to follow such a pattern. Where acreage is not available, mutually advantageous agreements between the dairymen and a neighbor cultivator could be formed for disposal of dairy wastes.

Sumps, holding ponds, and reservoirs holding manure wastes should be protected from flood flows. No pipes, drains or ditches from the milk barn should be allowed to drain in or near a stream channel.

Specific Regional Board policies pertaining to animal confinement operations can be found under "Control Actions" in Chapter Five.

VIII.C.3. IRRIGATION OPERATIONS - NEED FOR SALT MANAGEMENT

Salts originate by dissolution of the more soluble portions of rocks and soil particles in rain water (weathering). Such salts are transported in solution, but are concentrated in soils, waters, and so-called salt sinks due to evaporation from soil and water surfaces and transpiration (use) by crops (plants). This removal of water by evaporation or transpiration leaves salts behind. Salts are concentrated by each successive evaporative loss of water. In time, accumulations of salt can go from no- problem to extreme-problem levels unless some controls are applied.

For irrigated agriculture to continue production into the foreseeable future, this problem of gradual accumulation of salts in soils and waters must be faced and kept under control at acceptable levels. Otherwise, production will decline even under the best management, and no added amount of good management will be able to continue production of the quantities of food crops needed. In most of California's water basins, the rate of export or removal of salts from the basin will need to be

increased to more closely match or exceed the rate of salt accumulation. For each basin, not only do the rates of import and export of salts need to be in reasonably close balance, but the balance must also be maintained at a sufficiently low level of salinity to meet the quality demands of the various designated beneficial uses. This is often referred to as maintenance of a "favorable salt balance."

The rate of water quality degradation within a basin which results from inadequate salt exports is slow. It may be so slow that the need for control of salts is believed to be far into the future and of no concern to present planning. However, just as degradation may be a slow process, correction of a critical basin-wide salinity problem is also an extremely slow process. Good planning, now, to control this long-term, slow degradation of our soil and water resources seems the better course of action, rather than to wait until the problem becomes critical. Decisions made, or not made, now can be critical to control in the future.

Agriculture's need for salt management is both for on-farm management and for off-farm (basin-wide) management. The absolute need for discharge of salts by agriculture will create conflicts with other water users - even other agricultural water users.

Compromises and trade-offs will be necessary to reconcile these conflicts; however, necessary motivation for change in management at the farm level will need to be tied to dollars and the economic consequences of "no- change." If required agricultural management changes for essential pollution control result in added costs to the farmer, he has the same hard choices of any other businessman:

1. Absorb the cost with reduced profit

2. Pass on the cost in increased prices to consumers

3. Accept some form of public subsidy to off-set cost

4. Go out of business

5. Change crops grown

In coastal higher rainfall areas, irrigated agriculture could probably continue almost indefinitely, since irrigation would be used primarily during dry summer periods to supplement winter rainfall. Rainfall would be sufficient to flush salts through soils and provide adequate recharge and outflow from the underground water basin toward the ocean for salt control. There is more cause for concern in the drier inland areas such as the Salinas River Sub-basin and in the naturally mineralized ground water areas such as the Santa Maria Valley.

VIII.C.4. IMPROVED SALT MANAGEMENT TECHNIQUES

A concept of minimal degradation should be considered in some areas, but this will need to be coupled with management of the surface and ground water supplies to minimize and correct the effects of degradation that may occur. If complete correction is not possible, improved management will delay the time when salts reach critical levels. Several options available to correct degradation through improved salt management follow.

Improved irrigation efficiency would reduce both potential and actual pollutants in the water moving from surface to ground. Improved efficiency would also reduce total quantities of salts leaching to the water table and cut down on withdrawals or diversions from the limited water supply. Present statewide efficiency of water use may average 50 to 60 percent, but individual uses will vary from an estimated low of 30 percent where water is plentiful and inexpensive to a high of 95 percent where water quantity is limited and/or the price is high.

Implementation of the Leaching Requirement reported by U.S. Salinity Laboratory, Riverside, will help improve efficiency of irrigation. Other research data by this same laboratory has been reported on the effects of low leaching fractions in reduction of salt loads leaching to water tables. The new data offers real incentives to agriculture to improve irrigation efficiency in the form of real dollars saved by the farmer. Real water saved by agriculture can then be used for dilution, recharge, or nonagricultural uses. True, the salts moving to the water table under these low leaching fractions will be more concentrated, but due to low solubilities of

certain salts, a progressive precipitation and removal from solution occurs as the salt concentration in the percolating soil solution rises. As the concentration rises, considerable portions of the low solubility salts come out of solution, e.g., the relatively insoluble lime, dolomite, and slightly soluble gypsum.

With these low leaching fractions, salt load to the underground may be reduced as much as 50 percent in some cases. Sodium salts (sodium chloride, and sulfate) are not affected, so in relation to calcium and magnesium salts these sodium salts in the percolating waters increase. The compounds which precipitate are deposited in the lower root zone or below and cause no problem to agriculture except for a few specialized situations which are correctable (lime induced chlorosis). The increased proportions of sodium salts (higher SAR) will not reduce permeabilities of subsoils since salinity remains high enough to continue normal permeabilities of subsoils. The higher sodium (SAR) reaching water tables may reduce hardness slightly, but is not expected to be a problem to users of the underground waters.

Crop production can continue into the foreseeable future in the low rainfall areas if the minimal degradation that almost inevitably will occur is offset (a) by recharge and replenishment of the underground which will furnish dilution water for the added salts and (b) by drainage or removal of degraded waters at a sufficient rate to maintain low salt levels and achieve a satisfactory balance between salts coming into the basin and salts leaving the basin.

To help in recharge and dilution, additional winter runoff can be stored in surface reservoirs for later use for either surface stream or underground water quantity/quality enhancement or maintenance, e.g., Nacimiento and Twitchell reservoirs. Possible future reservoirs may be located on the Arroyo Seco and Carmel rivers. Or winter runoff could be used directly for ground water recharge to enhance flushing and flow-through dilution of salts and pollutants.

Drainage wells which discharge to drains leading to salt sinks are a possibility in removing salty waters, but these have had only limited success in draining high water table areas. However, they might be well adapted to ground water quality maintenance. Such wells could be drilled and operated to recover the salty top layers of water tables where salts are believed to accumulate as a layer of poorer quality water over the better quality deeper layers. Since most of the movement within water tables is thought to be horizontal and down slope, and vertical mixing is relatively slow, the possibility of recovering polluted upper layers of water tables should be explored as a quality maintenance tool or rejuvenation procedure for degraded water supplies.

Underdrains (tile systems) can aid in both water and salt management. Perched water tables intercept percolating salts, nutrients, and other pollutants and offer real possibilities as an aid in management and protection of the overall water quality of a basin. A "perched" water table is held up and separated from deeper aquifers by a relatively impermeable barrier (soil, rock, hardpan). This barrier often protects the deeper waters from pollution by preventing leakage of polluted waters from above. Perched water tables exist in portions of several basins. Salts and nutrients collected in these perched water tables may be tapped by underdrains (tile systems) and transported through the basin drainage system to disposal sites.

Basin-wide or area-wide drainage systems will be needed in order to move unusable wastewaters to acceptable temporary or permanent disposal sites (salt sinks). On- farm drainage problems will normally be solved at individual farmer expense because of the economics involved--the cost is not prohibitive and the costs of "not-solving" the problem (reduced yields, changing cropping patterns, or going out of business) are unacceptable. The off-farm part of drainage, however, is too big for individual farmers to solve, and some form of collective, organized large scale action is needed. The off- farm problems include collection of discharges, rights-of-way for conveyance, building and maintenance of a drainage system, disposal site acquisition, and management for compliance with discharge requirements.

Acceptable temporary or permanent salt disposal sites (salt sinks) must be designated and used. The Pacific Ocean is the only acceptable sink for most of the Central Coastal Basin; however, Soda Lake and certain highly mineralized ground water basins may be acceptable. To be able to remove salts as required to maintain a low salinity level in any one basin, there must be some other basin or site that will accept the salts. These acceptor areas are

known as salt sinks. Without acceptable salt sinks, salt management becomes a long-term losing battle and a frustrating exercise in futility.

Other salt inputs to a basin can be reduced by improved management of other salt sources such as fertilizer, animal wastes, and soil amendments. Regulation may be required but an appreciable improvement can be expected by education of farmers to better understand and better utilize existing information and guidelines. A salt routing approach could be used in areas such as Pancho Rico Creek to permit discharge of highly mineralized wastewater during periods of high flow.

VIII.C.5. MUSHROOM FARM OPERATIONS

Mushroom farm operations present surface or ground water problems if not properly managed.

VIII.C.5.a. TYPICAL MUSHROOM FARM OPERATION

Compost is needed as a growing base medium to produce mushrooms. Typically compost is produced on-site from straw, horse manure, cottonseed meal, or other organic matter. During composting, the organic material breaks down into a useable protein source for mushrooms. Water, added to assist the composting process, is constantly leaching through compost piles. Once compost is ready for use, it is placed in mushroom growing trays. After mushroom harvesting, steaming and fumigation sterilize the growing house and spent compost. Spent compost is then removed to "spent compost storage areas" and marketed as a soil additive or disposed of in some other manner.

VIII.C.5.b. TYPES OF WASTES DISCHARGED

Composting operations are typically carried out on concrete composting slabs. Compost is frequently sprayed with water. Excess water typically drains into a sump. Normally, excess water is recycled by pumping it back to spray the pile. In summer very little runoff or leachate is produced from composting. During the rainy season the sump collects more runoff from the compost slab than is recycled. Discharge to drainage ways or containment sumps may result.

When mushroom beds are irrigated, excess water drains from concrete floors to drainage ways or disposal sumps. This water contains peat moss, soluble substances from beds, salt from salt pans (used to "sanitize" the footwear of persons entering the cultivating room), and whatever is on the floor, such as pesticide residues and mushroom stems, at the time the floor is washed.

Steam is used for tray sterilization and to heat and sterilize growing houses. Prior to entering boilers, water is softened and treated with an organic or inorganic corrosion and scale inhibitors. Salt is used as a water softener regenerant. Discharge of water softener regenerant and boiler blowdown to drainage ways or disposal sumps may occur.

Solid wastes consisting of pesticide bags, mushroom roots and stumps, cardboard boxes, spent compost, and general debris are generated by mushroom farms.

Some of the disinfectants, fungicides, and pesticides being sprayed on the floor, walls, and mushrooms are occasionally washed off during washdown of the facility. Generally, pesticides used in this business have a relatively short life.

VIII.C.5.c. POSSIBLE WATER QUALITY PROBLEMS

Compost leachate and irrigation/ washwater is high in biochemical oxygen demand (BOD). BOD is

generally considered high if the concentration exceeds 30 mg/l, but this can vary from situation to situation. If discharged to surface waters, these wastes may depress dissolved oxygen to a critical level, and provide a nutrient source for undesirable aquatic growth. Improper disposal may also cause impacts on ground water. Nitrates are a particular concern.

Discharges of water softener regenerant and boiler blowdown may degrade surface and ground waters if improperly disposed. These wastes are high in Total Dissolved Solids, Sodium, and Chloride concentrations. Boiler blow-down may also contain organic or inorganic corrosion and scale inhibitors which could present toxicity problems if improperly disposed. Solid wastes can be a problem if improperly disposed.

Disinfectants, fungicides, and pesticides do not appear to present water quality problems based on inspections and limited sampling. These biocides can be a problem if handled improperly. Surface water runoff entering mushroom farm operations can become contaminated if runoff contacts any of the sources described above.

VIII.C.5.d. ADDITIONAL CONCERNS

Wastes can create a nuisance. Public health can be jeopardized if vectors develop among solid wastes. Further, odors resulting from storage of wastes can become offensive and may obstruct the free use of neighboring property.

VIII.C.5.e. RECOMMENDATIONS

1. Spent irrigation/washwater and compost leachate may be reused to spray compost piles.

2. Spent irrigation/washwater, compost leachate, and contaminated surface water runoff should be collected for treatment, storage, and disposal in lined ponds, unless shown by geohydrologic analysis that ground water will not be affected. If needed, aeration should be provided to stabilize organic substances and prevent odor problems. Dissolved oxygen of 1.0 mg/l or more is recommended for storage ponds.

3. Mushroom farm wastes, excluding water softener regenerant, may be used to irrigate farm crops during dry weather months. When salt is properly handled, the sodium and chloride content of these waters should be suitable for this purpose. The discharger must demonstrate to the Regional Board that irrigation water will not degrade beneficial water uses.

4. When irrigation is utilized, application rates and irrigation practices should be suitable to the crops irrigated.

5. Water softener regenerant and boiler blowdown should be disposed of separately from spent irrigation/washwater. Since its volume is small and concentration of pollutants is high, it is best to evaporate the liquid on a lined drying bed, or provide a documented test by a registered Engineer or laboratory that the soils permeability in the disposal area is 10-6 cm/sec or less. Two drying beds should be used for the purpose of holding salt/regenerant liquid and boiler blowdown waste. Discharges to beds are alternated to allow sufficient drying time.

6. Drying bed residue from any disposal pond should be disposed at a suitable solid waste disposal site.

7. As an alternative, water softener regenerant and boiler blowdown can be hauled in liquid form to a suitable disposal site, or discharged to the ocean through a suitable outfall.

8. Chemical alternatives for sanitizing footwear to replace salt pans should be investigated by farm operators.

9. If used, salt sanitation pans should be at least 4 inches deep and elevated to prevent contact between salt and water. Salt solution should remain in pans until disposed. Spent salt

should be dumped into a sealed container and disposed at a suitable site.

10. Solid waste should be routinely collected and disposed at a suitable site.

VIII.C.5.f. PROHIBITIONS

The following activities are prohibited at mushroom farms:

1. Discharge of inadequately treated waste, including leachate, high BOD, high nutrient waste, and contaminated surface water runoff to drainage ways, surface waters, and ground waters.

2. Discharge of untreated water softener regenerant and boiler blowdown waste in a manner that pollutes any non-saline surface or ground water.

3. Discharge and/or storage of waste, including spent compost, in a manner promoting nuisance and vector development.

4. Disposal of sludges, salt residues, pesticide residues, and solid waste in a manner not accepted by the Regional Board.

VIII.C.6. RANGE MANAGEMENT

Rangeland is the most extensive land use type in California, accounting for more than 40 million acres of the State's 101 million acres. As most of the rangelands are located between forested areas and major river systems, nearly all surface waters in the State flow through rangelands. Thus, rangeland activities can greatly impact water quality. In this section, grazing activities are discussed.

VIII.C.6.a. GRAZING

Grazing activities (particularly overgrazing), by contributing excessive sediment, nutrients, and pathogens, can adversely impact water quality and impair beneficial uses. Soil erosion and sedimentation are the primary causes of lowered water quality from rangelands. When grazing removes most of the vegetative cover from pastures and rangelands, the soil surface is exposed to erosion from wind and water. With runoff, eroded soil becomes sediment which can impair stream uses and alter stream channel morphology and results in decreased recharge capacity through clogging of channel bottoms. With steep slopes, highly erodible soils and interim storm events, the sediment delivery ratio (a measure of the amount of eroded soil delivery to a waterbody) on rangeland can be very high. Streambank erosion and lakeshore erosion are other sources of sediment on rangelands. Lakeshores, streambanks, and associated riparian zones are often subjected to heavy livestock use. Trampling and grazing of vegetation contribute to lakeshore and streamside instability as well as accelerated erosion.

Sediments can contribute large amounts of nutrients to surface water. Nutrients, mainly nitrogen and phosphorous, from manure and decaying vegetation also enter surface waters, particularly during runoff periods. Very critical nutrient problems can develop where livestock congregate for water, feed, salt, and shade. Pasture fertilization can also be a source of nutrients to surface waters, as well as a source of pesticides, particularly if flood irrigation techniques are used on rangelands.

Stream zone and lakeshore areas are important for water quality protection in that they can "buffer" (intercept and store nutrients which have entered surface and ground waters from upgradient areas). These "buffer zones" are more sensitive to processes which can increase nutrient discharges such as soil compaction, soil erosion, and vegetation damage than other areas of the rangeland.

Localized contamination by pathogens that could impact human health in surface water, ground water, and soils can result from livestock in pastures and rangelands. Rangeland streams can show

increased coliform bacterial levels with fecal coliform levels tending to increase as intensity of livestock use increases. Fecal coliform serve as indicators that pathogens could exist and flourish. The extent of contamination is usually determined by livestock density, sizing, and frequency of grazing, and access to the surface waters.

GRAZING CONTROL MEASURES

Grazing activities occur on both public and private lands in the Central Coast Region. Regulation of grazing on federal lands differs from that on private lands.

Federal lands -- Grazing activities on federal lands are regulated by the responsible land management agency, such as the U. S. Bureau of Land Management or the U.S. Forest Service. Through Memorandum of Understandings and Management Agency Agreements, the Regional Board recognizes the water quality authority of the U.S. Forest Service and U.S. Bureau of Land Management in range management activities on federal lands. Both these agencies require allotment management plans to be prepared for a specific area and for an individual permittee. The Regional Board relies on the water quality expertise of these agencies to include appropriate water quality measures in the allotment management plans. Most allotment management plans include specific Best Management Practices to protect water quality and existing and potential beneficial uses.

Non-federal (private) lands -- The Range Management Advisory Committee is a statutory committee which advises the California Board of Forestry on rangeland resources. The Committee has identified water quality protection as a major rangeland issue and has assumed a lead role in developing a Water Quality Management Plan for private rangelands in California. Regional Board staff is participating in the Plan's development. Sections proposed for inclusion in the Plan are status of water quality and soil stability on State rangelands, authority, mandates, and programs for water quality and watershed protection, local water quality planning guidelines, sources of assistance, development of management measures (Best Management Practices), State agency water quality responsibilities, and monitoring guidelines. Upon its completion, the Plan will be submitted to the State Board. On private lands whose owners request assistance, the U.S. Soil Conservation Service, in cooperation with the local Resource Conservation Districts, can provide technical and financial assistance for range and water quality improvement projects. A Memorandum of Understanding is in place between the U.S. Soil Conservation Service and the State Board for planning and technical assistance related to water quality actions and activities undertaken to resolve nonpoint source problems on private lands.

On both public and private lands, the Regional Board encourages grazing strategies that maintain adequate vegetative cover to reduce erosion and sedimentation. The Regional Board promotes dispersal of livestock away from surface waters as an effective means of reducing nutrient and pathogen loading. The Regional Board encourages use of Best Management Practices to improve water quality, protect beneficial uses, protect stream zone and lakeshore areas, and improve range and watershed conditions including:

- Implementing rest-rotation grazing strategies,
- Changing the season of use (on/off dates),
- Limiting the number of animals,
- Increasing the use of range riders to improve animal distribution and use of forage,
- Fencing to exclude grazing in sensitive areas,
- Developing non-lakeshore and non-stream zone watering sites,
- Constructing physical improvement projects such as check dams, and
- Restoring riparian habitat.

These same Best Management Practices may result in improved range and increased forage production, resulting in increased economic benefit to the rancher and land owner. The Regional Board also encourages land owners to develop appropriate site-specific Best Management Practices using the

technical assistance of the U.S. Soil Conservation Service and the U.S. EPA.

In addition to relying on the grazing management expertise of agencies such as the U.S. Forest Service, U.S. Bureau of Land Management, or Range Management Advisory Committee, the Regional Board can directly regulate grazing activities to protect water quality. Actions available to the Regional Board include:

1. Require that a Report of Waste Discharge be filed, that allotment management plans for specific federal lands be prepared, or that a Coordinated Resource Management Plan be adopted within one year of problem documentation. Such problems indicate impairment of beneficial uses or violation or threatened violation of water quality objectives.

2. Require that all allotment management plans (utilized for federal lands) and Coastal Resource Management Plans contain Best Management Practices necessary to correct existing water quality problems or to protect water quality so as to meet all applicable beneficial uses and water quality objectives contained in Chapters Two and Three, respectively, of this Basin Plan. Corrective measures would have to be implemented within one year of submittal of the allotment management plan or Coastal Resource Management Plan, except where staged Best Management Practices are appropriate. Implementation of a staged Best Management Practice must commence within one year of submittal of the allotment management plan or Coastal Resource Management Plan.

3. Require that each allotment management plan (utilized for federal lands) or Coastal Resource Management Plan include specific objectives, actions, and monitoring and evaluation procedures. The discussion of actions must establish the seasons of use, number of livestock permitted, grazing system(s) to be used, a schedule for rehabilitation of ranges in unsatisfactory condition, a schedule for initiating range improvements, and a schedule for maintenance of range improvements must include priorities and planned completion dates. The discussion of monitoring and evaluation must propose a method and timetable for reporting of livestock forage conditions, watershed condition, and surface and ground water quality.

4. Require that all allotment management plans and Coastal Resource Management Plans be circulated to interested parties, organizations, and public agencies.

5. Consider adoption of waste discharge requirements if an allotment management plan or Coastal Resource Management Plan is not prepared or if the Executive Officer and the landowner do not agree on Best Management Practices proposed in an allotment management plan or Coastal Resource Management Plan.

6. Decide that allotment management plans and Coastal Resource Management Plans prepared to address a documented watershed or water quality problem may be accepted by the Regional Board's Executive Officer in lieu of adoption of Waste Discharge Requirements.

7. Oversee monitoring of water quality variables and beneficial uses. Provide data interpretation.

8. Encourage the U.S. Bureau of Land Management, U.S. Forest Service, Resource Conservation District, and private landowners to develop watering sites for livestock away from Lake shores, stream zones, and riparian areas.

9. Encourage private landowners to request technical and financial assistance from U.S. Soil Conservation Service, in cooperation with the local Resource Conservation Districts, in the preparation of allotment management plans and the implementation or construction of grazing and water quality improvements.

10. Continue to coordinate with the Range Management Advisory Committee in the development of a water quality management plan for private rangelands.

VIII.D. INDIVIDUAL, ALTERNATIVE, AND COMMUNITY DISPOSAL SYSTEMS

On-site sewage disposal systems and other similar methods for liquid waste disposal are sometimes viewed as interim solutions in urbanizing areas, yet may be required to function for many years. On-site systems can be a viable long-term waste disposal method with proper siting, design, construction, and management. In establishing on- site system regulations, agencies must consider such systems as permanent, not interim systems to be replaced by public sewers. The reliability of these systems is highly dependent on land and soil constraints, proper design, proper construction, and proper operation and maintenance.

If on-site sewage treatment facilities are not carefully managed, problems can occur, including:

- odors or nuisance;
- surfacing effluent;
- disease transmission; and,
- pollution of surface and ground waters.

Odors and nuisance can be objectionable and annoying and may obstruct free use of property. Surfacing effluent (effluent which fails to percolate and rises to the ground surface) can be an annoyance, or health hazard to the resident and neighbors. In some cases, nearby surface waters may be polluted.

On-site sewage disposal systems are a potential mechanism for disease transmission. Sewage is capable of transmitting diseases from organisms which are discharged by an infected individual. These include dysentery, hepatitis, typhoid, cholera, and gastro-intestinal disorders.

Pollution of surface or ground waters can result from the discharge of on-site system wastes. Typical problem waste constituents are total dissolved solids, phosphates, nitrates, heavy metals, bacteria, and viruses. Discharge of these wastes will, in some cases, destroy beneficial surface and ground water uses.

Subsurface disposal systems may be used to dispose of wastewater from: (1) individual residences; (2) multi-unit residences; (3) institutions or places of commerce; (4) industrial sanitary sources; and, (5) small communities. All individual and multi- unit residential developments are subject to criteria in this section of the Basin Plan. Commercial, institutional, and industrial developments with a discharge flow rate less than 2500 gallons per day generally are not regulated by waste discharge requirements; therefore, they must comply with these criteria. Community systems must also comply with criteria relating to this subject within the Basin Plan. Community systems are defined for the purposes of this Basin Plan as: (1) residential wastewater treatment systems for more than 5 units or more than 5 parcels; or, (2) commercial, institutional or industrial systems to treat sanitary wastewater equal to or greater than 2500 gallons per day (average daily flow). Systems of this type and size may be subject to waste discharge requirements.

Alternatives to conventional on-site system designs have been used when site constraints prevent the use of conventional systems. Examples of alternative systems include mound and evapotranspiration systems. Remote subdivisions, commercial centers, or industries may utilize conventional collection systems with community treatment systems and subsurface disposal fields for sanitary wastes. Alternative and community systems can pose serious water quality problems if improperly managed. Failures have been common in the past and are usually attributed to the following:

- Systems are inadequately or improperly sited, designed, or constructed.
- Long-term use is not considered.
- Inadequate operation and maintenance.

VIII.D.1. CORRECTIVE ACTIONS FOR EXISTING SYSTEMS

Individual disposal systems can be regulated with relative ease when they are proposed for a particular site. For new systems, regulations generally provide for good design and construction practices. A more troublesome problem is presented by older septic tank systems where design and construction may have been less strictly controlled or where land development has intensified to an extent that percolation systems are too close together and there is no room left for replacement leaching areas. Where this situation develops to an extent that public health hazards and nuisance conditions develop, the most effective remedy is usually a sewer system. Where soil percolation rates are particularly fast, ground water degradation is possible, particularly increases in nitrate concentrations.

Sewer system planning should be emphasized in urbanizing areas served by septic tanks. A first step would be a monitoring system involving surface and ground waters to determine whether problems are developing. Where septic tank systems in urbanized areas are not scheduled for replacement by sewers and where public health hazards are not documented, septic tank maintenance procedures are encouraged to lessen the probability that a few major failures might force sewering of an area which otherwise could be retained on individual systems without compromising water quality. Often a few systems will fail in an area where more frequent septic tank pumping, corrections to plumbing or leach fields, or in-home water conservation measures could help prevent failure. Improvements of this kind should be enforced by a local septic tank maintenance district or local governing jurisdiction.

A septic tank subjected to greater hydraulic load can fail due to washout of solids into percolation areas and plugging of the infiltrative surface. In some cases, excess wash water could be diverted to separate percolation areas by in-home plumbing changes. Dishwashers, garbage grinders, and washing machines could be eliminated. Water saving toilets, faucets, and shower heads are available to encourage low water use. Water use costs may also be structured to encourage more frugal use of water.

VIII.D.2. LOCAL GOVERNING JURISDICTION ACTIONS

VIII.D.2.a. DISCLOSURE AND COMPLIANCE OF EXISTING WASTEWATER DISPOSAL SYSTEM

Local governing jurisdictions should provide programs to assure conformance with this Basin Plan and local regulations. Inspection programs should assure site suitability tests are performed as necessary, and that tests are in accordance with standard procedures. Inspection should also assure proper system installation. Proper design and construction should be certified by the inspector. Concerned homeowners can be a tremendous asset in assuring proper construction. When a septic system permit is issued by the local agency, a handout specifying proper construction techniques should be made available to the general public. Systems must be inspected by the local agency before covering (backfilling).

Local agencies can use either staff inspectors or individuals under contract with the local government. Either way, a standard detailed checklist should be completed by the inspector to certify compliance.

Site suitability determinations should specify: (1) whether approval is for the entire lot or for specific locations of the lot; (2) if further tests are necessary; and, (3) if alternatives are necessary or available.

Where agency approval is necessary from various departments, final sign-offs should be on the same set of plans.

Home owners should be aware of the nature and requirements of their wastewater disposal system. Plans should be available in city or county offices showing placement of soil absorption systems. Since this is only feasible for new construction, local agencies should require septic system as-built plans

as a condition of new construction final inspection. Plans would be kept on file for future use of property owners.

Prospective property buyers should be informed of any enforcement action affecting parcels or houses they wish to buy. For example, a parcel in a discharge prohibition area may be unbuildable for an indefinite period, or a developed parcel may be subject to significant user charges from a future sewer system. Local agencies should have prohibition area terms entered into the county record for each affected parcel. When a prospective buyer conducts a title search, terms of the prohibition would appear in the preliminary title report.

Dual leaching capabilities provide an immediate remedy in the event of system failure. For that reason, dual leachfields are considered appropriate for all systems. Furthermore, should wastewater flows increase, this area can be used until the system is expanded. But system expansion may not be possible if land is not set aside for this purpose. For these reasons, dedicated system expansion areas are also appropriate.

To protect this set-aside area from encroachment, the local agency should require restrictions on future use of the area as a condition of land division or building permit approval. For new subdivisions, Covenants, Conditions, and Restrictions (CC&R's) might provide an appropriate mechanism for protecting a set aside area. Future buyers of affected property would be notified of property use restrictions by reading CC&R's.

All on-site system owners need to be aware of proper operation and maintenance procedures. Local governing jurisdictions should mount a continuing public education program to provide home owners with on-site system operation and maintenance guidelines. Basin Plan information should be available at local agency health and building departments.

Local agencies should conduct an on-site system inspection program, particularly in areas where system failures are common or where systems with poor soils are approved. An agency inspector should periodically check each septic tank for pumping need and each system for proper operation. Homeowners should be alerted where evidence of system failure exists. Where nuisance or a potential public health hazard exists, a followup procedure should insure the situation is corrected. On-site systems should be constructed in a location that facilitates system inspection.

Another approach is periodically to mail homeowners a brochure reminding them how to maintain and inspect their on-site system. Homeowners should be notified that they should periodically check their septic tank for pumping need. Homeowners should also be notified of other problems indicative of system failure. Some examples include wet spots in drainfield area, lush grass growths, slowly draining wastewater, and sewage odors.

Many existing systems do not comply with current or proposed standards. Repairs to failing systems should be done under permit from the local agency. To the extent practicable, the local agency should require failing systems to be brought into compliance with Basin Plan recommendations. This could be a condition of granting a permit for repairs.

Land use changes on properties used for commerce, small institutions, or industries should not be approved by the local agency until the existing on-site system meets criteria of this Basin Plan and local ordinances. A land use permit or business license could be used to alert the local agency of land use changes.

VIII.D.2.b. ON-SITE WASTEWATER MANAGEMENT PLANS

On-site wastewater management should be implemented in urbanizing areas to investigate long-term cumulative impacts resulting from continued use of individual, alternative, and community on-site disposal systems. A wastewater disposal study should be conducted to determine the best Wastewater Management Plan that would provide site or basin specific wastewater re-use. This study should identify basin specific criteria to prevent water quality degradation and public health hazards and provide an evaluation of the effects of existing and proposed developments and changes in land use. These plans should be a comprehensive planning tool to specify on-site disposal system limitations to prevent ground or surface water

degradation. Wastewater management plans should:

- Contain a ground/surface water monitoring program.
- Identify sites suitable for conventional septic systems.
- Project on-site disposal system demand.
- Determine sites and methods to best meet demand.
- Project maximum population densities for each subdrainage basin to control degradation or contamination of ground or surface water.
- Recommend establishment of septic tank maintenance districts, as needed.
- Identify alternate means of disposing of sewage in the event of irreversible degradation from on-site disposal systems.

For areas where watershed-wide plans are not developed, conditions could be placed on new divisions of land or community systems to provide monitoring data or geologic information to contribute to the development of a Wastewater Management Plan.

Wastewater disposal alternatives should identify costs to each homeowner. A cost-effectiveness analysis, which considers socio-economic impacts of alternative plans, should be used to select the recommended plan.

On-site wastewater disposal zones, as discussed in Section 6950-6981 of the Health and Safety Code, may be an appropriate means of implementing on-site Wastewater Management Plans.

On-site Wastewater Management Plans shall be approved by the Regional Board.

VIII.D.2.c. SEPTIC TANK MAINTENANCE DISTRICTS

It may be appropriate for unsewered community on-site systems to be maintained by local sewage disposal maintenance districts. These special districts could be administered through existing local governments such as County Water Districts, a Community Services District, or a County Service Area.

Septic tank maintenance districts should be responsible for operation and maintenance in conformance with this Water Quality Control Plan. Administrators should insure proper construction, installation, operation, and maintenance of on-site disposal systems. Maintenance districts should establish septic tank surveillance, maintenance and pumping programs, where appropriate; provide repairs to plumbing or leachfields; and encourage water conservation measures.

VIII.D.3. CRITERIA FOR NEW SYSTEMS

On-site sewage disposal system problems can be minimized with proper site location, design, installation, operation, and maintenance. The following section recommends criteria for all new individual subsurface disposal systems and community sewage disposal systems. Local governing jurisdictions should incorporate these guidelines into their local ordinances. These recommendations will be used by the Regional Board for Regional Board regulated systems and exemptions.

Recommendations are arranged in sequence under the following categories: site suitability; system design; construction; individual system maintenance; community system design; and local agencies.

Mandatory criteria are listed in the "Individual, Alternative, and Community Systems Prohibitions" section.

VIII.D.3.a. SITE SUITABILITY

Prior to permit approval, site investigation should determine on-site system suitability:

1. At least one soil boring or excavation per on-site system should be performed to determine soil suitability, depth to ground water, and depth to bedrock or impervious layer. Soil borings are particularly important for seepage pits. Impervious material is defined as having a percolation rate slower than 120 minutes per inch or having a clay content 60 percent or greater. The soil boring or excavation should extend at least 10 feet below the drainfield1 bottom at each proposed location.

2. An excavation should be made to detect mottling or presence of underground channels, fissures, or cracks. Soils should be excavated to a depth of 4-5 feet below drainfield bottom.

3. For leachfields, at least three percolation test locations should be used to determine system acceptability. Tests should be performed at proposed subsurface disposal system sites and depths.

4. If no restrictive layers intersect, and geologic conditions permit surfacing, the setback distance from a cut, embankment, or steep slope (greater than 30 percent) should be determined by projecting a line 20 percent down gradient from the sidewall at the highest perforation of the discharge pipe. The leachfields should be set-back far enough to prevent this projected line from intersecting the cut within 100 feet, measured horizontally, of the sidewall. If restrictive layers intersect cuts, embankments or steep slopes, and geologic conditions permit surfacing, the setback should be at least 100 feet measured from the top of the cut.

5. Natural ground slope of the disposal area should not exceed 20 percent.

6. For new land divisions, lot sizes less than one acre should not be permitted.

VIII.D.3.b. SYSTEM DESIGN

On-site systems should be designed according to the following recommendations:

1. Septic tanks should be designed to remove nearly 100 percent of settleable solids and should provide a high degree of anaerobic decomposition of colloidal and soluble organic solids.

2. Tank design must allow access for inspection and cleaning. The septic tank must be accessible for pumping.

3. If curtain drains discharge diverted ground water to subsurface soils, the upslope separation from a leachfield or pit should be 20 feet and the down slope separation should be 50 feet.

4. Leachfield application rate should not exceed the following:

Percolation Rate min./in	Loading Rate g.p.d./sq.ft.
1 - 20	0.8
21 - 30	0.6
31 - 60	0.25
61 - 120	0.10

5. Seepage pit application rate should not exceed 0.3 gpd/sq. ft.

6. Drainfield[1] design should be based only upon usable permeable soil layers.

7. The minimum design flow rate should be 375 gallons per day per dwelling unit.

8. In clayey soils, systems should be constructed to place infiltrative surfaces in more permeable horizons.

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1 "Drainfield" refers to either a leachfield or seepage pit

9. Distance between drainfield trenches should be at least two times the effective trench depth.[1]

10. Distance between seepage pits (nearest sidewall to sidewall) should be at least 20 feet.

11. Dual disposal fields (200 percent of original calculated disposal area) are recommended.

12. For commercial systems, small institutions, or sanitary industrial systems, design should be based on daily peak flow.

13. For commercial and institutional systems, pretreatment may be necessary if wastewater is significantly different from domestic wastewater.

14. Commercial systems, institutional systems, or domestic industrial systems should reserve an expansion area (i.e. dual drainfields must be installed and area for replacement of drainfield must be provided) to be set aside and protected from all uses except future drainfield repair and replacement.

15. Nutrient and heavy metal removal should be facilitated by planting ground cover vegetation over shallow subsurface drainfields. The plants must have the following characteristics: (1) evergreen, (2) shallow root systems, (3) numerous leaves, (4) salt resistant, (5) ability to grow in soggy soils, and (6) low or no maintenance. Plants downstream of leaching area may also be effective in nutrient removal.

VIII.D.3.c. DESIGN FOR ENGINEERED SYSTEMS

1. Mound systems should be installed in accordance with criteria contained in Guidelines for Mound Systems by the State Water Resources Control Board.

2. Evapotranspiration systems should be installed in accordance with criteria contained in Guidelines for Evapotranspiration Systems by the State Water Resources Control Board. Exceptions are:

   a. For evapotranspiration systems, each month of the highest precipitation year and lowest evaporation year within the previous ten years of record should be used for design.

   b. Systems shall be designed by a registered civil engineer competent in sanitary engineering.

VIII.D.3.d. CONSTRUCTION

Water quality problems resulting from improper construction can be reduced by following these practices:

1. Subsurface disposal systems should have a slightly sloped finished grade to promote surface runoff.

2. Work should be scheduled only when infiltrative surfaces can be covered in one day to minimize windblown silt or rain clogging the soil.

3. In clayey soils, work should be done only when soil moisture content is low to avoid smeared infiltrative surfaces.

4. Bottom and sidewall areas should be left with a rough surface. Any smeared or compacted surfaces should be removed.

5. Bottom of trenches or beds should be level throughout to prevent localized overloading.

6. Two inches of coarse sand should be placed on the bottom of trenches to prevent compacting soil when leachrock is dumped into drainfields. Fine sand should not be used as it may lead to system failure.

7. Surface runoff should be diverted around open trenches/ pits to limit siltation of bottom area.

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1 "Effective trench depth" means depth below the bottom of the trench pipe.

8. Prior to backfilling, the distribution system should be tested to check the hydraulic loading pattern.

9. Properly constructed distribution boxes or junction fittings should be installed to maintain equal flow to each trench. Distribution boxes should be placed with extreme care outside the leaching area to insure settling does not occur.

10. Risers to the ground surface and manholes should be installed over the septic tank inspection ports and access ports.

11. Drainfield should include an inspection pipe to check water level.

Additional construction precautions are discussed within the Environmental Protection Agency's Design Manual: On-Site Wastewater Treatment and Disposal Systems.

VIII.D.3.e. INDIVIDUAL SYSTEM MAINTENANCE

Individual septic tanks should be maintained as follows:

1. Septic tanks should be inspected every two to five years to determine the need for pumping. If garbage grinders or dishwashers discharge into the septic tank, inspection should occur at least every two years.

2. Septic tanks should be pumped whenever: (1) the scum layer is within three inches of the outlet device; or (2) the sludge level is within eight inches of the bottom of the outlet device.

3. Drainfields should be alternated when drainfield inspection pipes reveal a high water level.

4. Disposal of septage (solid residue pumped from septic tanks) should be accomplished in a manner acceptable to the Executive Officer. In some areas, disposal may be to either a Class I or Class II solid waste site; in others, septage may be discharged to a municipal wastewater treatment facility.

VIII.D.3.f. COMMUNITY SYSTEM DESIGN

Community systems should be designed and maintained to accommodate the following items:

1. Capacities should accommodate build-out population.

2. Design should be based upon peak daily flow estimates.

3. Design should consider contributions from infiltration throughout the collection system.

4. Septic tanks should be pumped when sludge and scum levels are greater than 1/3 of the depth of the first compartment.

5. Operation and maintenance should be in accordance with accepted sanitary practice.

6. Maintenance manuals should be provided to system users and maintenance personnel.

7. Discharge should not exceed 40 grams per day total nitrogen, on the average, per acre of total development overlying ground water recharge areas, unless local governing jurisdictions adopt Wastewater Management Plans subsequently approved by the Regional Board.

VIII.D.3.g. LOCAL AGENCIES

Recommendations for local governing jurisdictions:

1. Adopt a standard percolation test procedure.

   The California State Water Resources Control Board Guidelines for Evapotranspiration Systems provides a percolation test method recommended for use to standardize test

results. A twelve-inch diameter percolation test hole may be used.

2. Percolation tests should be continued until a stabilized rate is obtained.

3. Percolation test holes should be drilled with a hand auger. A hole could be hand augered or dug with hand tools at the bottom of a larger excavation made by a backhoe.

4. Percolation tests should be performed at a depth corresponding to the bottom of the subsurface disposal area.

5. Seepage pits should be utilized only after careful consideration of site suitability. Soil borings or excavations should be inspected either by permitting agency or individual under contract to the permitting agency.

6. Approve permit applications after checking plans for erosion control measures.

7. Inspect systems prior to covering to assure proper construction.

8. Require replacements or repairs to failing systems to be in conformance with Basin Plan recommendations, to the extent practicable.

9. For new land divisions, protect on-site disposal systems and expansion areas from encroachment by provisions in covenants, conditions, and restrictions.

10. Inform property buyers of the existence, location, operation, and maintenance of on-site disposal systems. Prospective home or property buyers should also be informed of any enforcement action (e.g. Basin Plan prohibitions) through the County Record.

11. Conduct public education programs to provide property owners with operation and maintenance guidelines.

12. Alternative system owners shall be provided an informational maintenance or replacement document by the appropriate governing jurisdiction. This document shall cite homeowner procedures to ensure maintenance, repair, or replacement of critical items within 48 hours following failure.

13. Where appropriate, septic tank systems should be maintained by local septic tank maintenance districts.

14. Wastewater Management Plans should be prepared and implemented for urbanizing and high density areas, including applicable portions of San Martin, San Lorenzo Valley, Carmel Valley, Carmel Highland, Prunedale, El Toro, Shandon, Templeton, Santa Margarita/Garden Farms, Los Osos/Baywood Park, Arroyo Grande, Nipomo, upper Santa Ynez Valley, and Los Olivos/Ballard.

15. Ordinances should be updated to reflect Basin Plan criteria.

VIII.D.3.h. ADDITIONAL CONSIDERATIONS

1. Water conservation and solids reduction practices are recommended. Garbage grinders should not be used in homes with septic tanks.

2. Metering and water use costs should be used to encourage water conservation.

3. Grease and oil should not be introduced into the system. Bleach, solvents, fungicides, and any other toxic material should not be poured into the system.

4. Reverse osmosis unit blow-down should not be discharged to on-site wastewater treatment systems overlying usable ground water. Off-site (factory regeneration) practices are recommended for water softeners.

5. If on-site water softener regeneration is necessary, minimum salt use in water softeners is recommended. This can be accomplished by minimizing regeneration time or limiting the number of regeneration cycles.

VIII.D.3.i. INDIVIDUAL, ALTERNATIVE AND COMMUNITY SYSTEMS PROHIBITIONS

Discharges from new soil absorption systems installed after September 16, 1983 in sites with any of the following conditions are prohibited:

1. Soils or formations contain continuous channels, cracks, or fractures.1

2. For seepage pits, soils or formations containing 60 percent or greater clay (a soil particle less than two microns in size) unless parcel size is at least two acres.

3. Distances between trench bottom and usable ground water, including perched ground water, less than separation specified by appropriate percolation rate:

Percolation Rate, min/in	Distance, ft
<1	50[1]
1-4	20[1]
5-29	8
>30	5

4. For seepage pits, distances between pit bottom and usable ground water, including perched ground water, less than separation specified by appropriate soil type:

Soil	Distance,ft.
Gravels[2]	50[1]
Gravels with few fines[3]	20[1]
Other	10

5. Distances between trench/pit bottom and bedrock or other impervious layer less than ten feet.

6. For leachfields, where percolation rates are slower than 120 min/in, unless parcel size is at least two acres.

7. For leachfields, where soil percolation rates are slower than 60 min./in. unless the effluent application rate is 0.1 gpd/ft2 or less.

8. Areas subject to inundation from a ten-year flood.

9. Natural ground slope of the disposal area exceeds 30 percent.

10. Setback distances less than:

	Minimum Setback Distance, ft
Domestic water supply wells in unconfined aquifer	100
Watercourse[4] where geologic conditions permit water migration	100
Reservoir[5] spillway elevation	200
Springs, natural or any part of man-made spring	100

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1 Unless a set-back distance of at least 250 feet to any domestic water supply well or surface water is assured.

2 Gravels - Soils with over 95 percent by weight coarser than a No. 200 sieve and over half of the coarse fraction larger than a No. 4 sieve.

3 Gravels with few fines - Soils with 90 percent to 94 percent coarse fraction larger than a No. 4 sieve.

4 Watercourse - (1) A natural or artificial channel for passage of water. (2) A running stream of water. (3) A natural stream fed from permanent or natural sources, including rivers, creeks, runs, and rivulets. There must be a stream, usually flowing in a particular direction (though it need not flow continuously) in a definite channel, having a bed or banks and usually discharging into some stream or body of water.

5 Reservoir- A pond, lake, tank, basin, or other space either natural or created in whole or in part by the building of engineering structures, which is used for storage, regulation, and control of water, recreation, power, flood control, or drinking.

11. While new septic tank systems should generally be limited to new divisions of land having a minimum parcel size of one acre, where soil and other physical constraints are particularly favorable, parcel size shall not be less than one-half acre.

12. Within a reservoir[1] watershed where the density for each land division is less than 2.5 acres for areas without approved Wastewater Management Plans.

13. For individual systems on new land divisions, and commercial, institutional, and sanitary industrial systems without an area set aside for dual leachfields (100 percent replacement area).

14. Commercial, institutional, or sanitary industrial systems not basing design on daily peak flow estimate.

15. Any site unable to maintain subsurface disposal.

16. Any subdivision unless the subdivider clearly demonstrates the use of the system will be in the best public interest, that beneficial water uses will not be adversely affected, and compliance with all Basin Plan prohibitions is demonstrated.

17. Lot sizes, dwelling densities or site conditions causing detrimental impacts to water quality.

18. Any area where continued use of on-site systems constitutes a public health hazard, an existing or threatened condition of water pollution, or nuisance.

Discharges from community subsurface disposal systems (serving more than five parcels or more than five dwelling units) are prohibited unless:

1 Seepage pits have at least 15 vertical feet between pit bottom and highest usable ground water, including perched ground water.

2. Sewerage facilities are operated by a public agency. (If a demonstration is made to the Regional Board that an existing public agency is unavailable and formation of a new public agency is unreasonable, a private entity with adequate financial, legal, and institutional resources to assume responsibility for waste discharges may be acceptable).

3. Dual disposal systems are installed (200 percent of total of original calculated disposal area).

4. An expansion area is included for replacement of the original system (300 percent total).

5. Community systems provide duplicate individual equipment components for components subject to failure.

6. Discharge does not exceed 40 grams per day of total nitrogen, on the average, per 1/2 acre of total development overlying ground water recharge areas excepting where a local governing jurisdiction has adopted a Wastewater Management Plan subsequently approved by the Regional Board.

In order to achieve water quality objectives, protect present and future beneficial water uses, protect public health, and prevent nuisance, discharges are prohibited in the following areas:

1. Discharges from individual sewage disposal systems are prohibited in portions of the community of Nipomo, San Luis Obispo County, which are particularly described in Appendix A-27.

2. Discharges from individual sewage disposal systems within the San Lorenzo River Watershed shall be managed as follows:

   a. Discharges shall be allowed, providing the County of Santa Cruz, as lead agency, implements the "Wastewater Management Plan for the San Lorenzo River Watershed, County of Santa Cruz, Health Services Agency, Environmental Health Service", February 1995 and "San Lorenzo Nitrate Management Plan, Phase II Final Report", February 1995, County of Santa Cruz, Health Services Agency, Environmental Health Service (Wastewater Management Plan) and assures the Regional Board that areas of the San Lorenzo River Watershed are serviced by wastewater disposal systems to protect and enhance water quality, to protect and restore beneficial uses of water, and to abate and prevent nuisance, pollution, and contamination.

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1 Reservoir – A pond, lake, tank, basin, or other space either natural or created in whole or in part by the building of engineering structures, which is used for storage, regulation, and control of water, recreation, power, flood control, or drinking.

In fulfilling the responsibilities identified above, the County of Santa Cruz shall submit annual reports beginning on January 15, 1996. The report shall state the status and progress of the Wastewater Management Plan in the San Lorenzo River Watershed. The County of Santa Cruz annual report shall document the results of:

a. Existing disposal system performance evaluations,
b. Disposal system improvements,
c. Inspection and maintenance of on-site systems,
d. Community disposal system improvements,
e. New development and expansion of existing system protocol and standards,
f. Water quality monitoring and evaluation,
g. Program administration management, and
h. Program information management.

The report shall also document progress on each element of the Nitrate Management Plan, including:

a. Parcel size limit,
b. Wastewater Management Plan implementation,
c. Boulder Creek Country Club Wastewater Treatment Plant Upgrade,
d. Shallow leachfield installation,
e. Enhanced wastewater treatment for sandy soils,
f. Enhanced wastewater treatment for large on-site disposal systems,
g. Inclusion of nitrogen reduction in Waste Discharge Permits,
h. Livestock and stable management,
i. Protection of ground water recharge areas,
j. Protection of riparian corridors and erosion control,
k. Nitrate control for new uses,
l. Scotts Valley nitrate discharge reduction, and
m. Monitoring for nitrate in surface and ground water.

3. Discharges from individual and community sewage disposal systems are prohibited effective November 1, 1988, in the Los Osos/Baywood Park area depicted in the Prohibition Boundary Map included as Attachment "A" of Resolution No. 83-13 which can be found in Appendix A-30.

VIII.D.3.j. SUBSURFACE DISPOSAL EXEMPTIONS

The Regional Board or Executive Officer may grant exemption to prohibitions for: (1) engineered new on- site disposal systems for sites unsuitable for standard systems; and (2) new or existing on-site systems within the specific prohibition areas cited above. Such exemptions may be granted only after presentation by the discharger of sufficient justification, including geologic and hydrologic evidence that the continued operation of such system(s) in a particular area will not individually or collectively, directly or indirectly, result in pollution or nuisance, or affect water quality adversely.

Individual, alternative, and community systems shall not be approved for any area where it appears that the total discharge of leachate to the geological system, under fully developed conditions, will cause: (1) damage to public or private property; (2) ground or surface water degradation; (3)nuisance condition; or, (4) a public health hazard. Interim use of septic tank systems may be permitted where alternate parcels are held in reserve until sewer systems are available.

Requests for exemptions will not be considered until the local entity has reviewed the system and submitted the proposal for Regional Board review. Dischargers requesting exemptions must submit a Report of Waste Discharge. Exemptions will be subject to filing fees as established by the State Water Code.

Engineered systems shall be designed only by registered engineers competent in sanitary engineering. Engineers should be responsible for proper system operation. Engineers should be responsible for educating system users of proper operation and maintenance. Maintenance schedules should be established. Engineered systems should be inspected by designer during installation to insure conformance with approved plans.

Some engineered systems may be considered experimental by the Regional Board. Experimental systems will be handled with caution. A trial period of at least one year should be established whereby proper system operation must be demonstrated. Under such an approach, experimental systems are granted a one year conditional approval.

Further information concerning individual, alternative, or community on-site sewage disposal systems can be found in Chapter 5 in the Management Principals and Control Actions sections. State Water Resources Control Board Plans and Policies, Discharge Prohibitions, and

Regional Board Policies may also apply depending on individual circumstances.

VIII.E. LAND DISTURBANCE ACTIVITIES

Construction, mining, and other soil disturbance activities which may disturb or expose soil or otherwise increase susceptibility of land areas to erosion are difficult to regulate effectively. Construction or timber harvesting may often begin and end with no obvious impairment of stream quality; however, erosion or land slides the following winter may be directly related to earlier land disturbance or tree cutting. Mining and quarrying activities are generally longer in duration.

Under contract with the Regional Board, the California Association of Resource Conservation Districts completed a study entitled, "Erosion and Sediment in California Central Coast Watersheds - A study of Best Management Practices" (Erosion Study), dated June, 1979. This Erosion Study, funded under Section 208 of the Clean Water Act, assesses impacts of erosion and sedimentation on water quality and beneficial uses in nondesignated planning areas (San Benito, San Luis Obispo, and Santa Barbara Counties) of the Central Coast Region. This Erosion Study and supporting documents have been used by the Regional Board in developing erosion and sedimentation control policy.

Nonpoint source pollution in the remainder of the Region is addressed by designated planning agencies through their respective Area wide Waste Treatment Management Plans. Designated agencies and the areas affected within this Region include: Association of Bay Area Governments (portions of San Mateo and Santa Clara Counties), Association of Monterey Bay Area Governments (Santa Cruz and Monterey Counties), and Ventura County Board of Supervisors (portion of Ventura County). The policy herein described is compatible with those plans and is within the scope of the Regional Board authority.

The Erosion Study and Area wide Waste Treatment Management Plans identify examples of accelerated erosion resulting from insufficient land management of soil cultivation, grazing, silvaculture, construction, and off-road vehicle activities, as well as wildfires.

Adverse impacts of sediment are identified, in part, as: impairment of water supplies and ground water recharge, siltation of streams and reservoirs, impairment of navigable waters, loss of fish and wildlife habitat, degradation of recreational waters, transport of pathogens and toxic substances, increased flooding, increased soil loss, and increased costs associated with maintenance and operation of water storage and transport facilities. Recommendations based on conclusions of the Erosion Study and practices recommended in Area wide Waste Treatment Management Plans are a means to reduce unnecessary soil loss due to erosion and to minimize adverse water quality impacts resulting from sediment.

When a practice or combination of practices is found to be the most effective, practical (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals, it is designated a Best Management Practice (BMP). BMPs are determined only after problem assessment, examination of alternative practices, and appropriate public participation in the BMP development process.

General recommendations based on conclusions of the Erosion Study are discussed below. These recommendations are considered to be Best Management Practices (BMPs) by the Regional Board as are the Area wide approved water quality management plans.

1. Soil conservation control measures should be used to minimize impacts that would otherwise result from soil erosion. Control measures are identified according to systems, which are then broken down into subsystems of erosion control techniques or component measures.

   For example, a system for control of erosion from construction sites would identify component measures such as debris basins, access roads, hillside ditches, etc. Other conservation control systems include: conservation cropping, conservation irrigation, roadside erosion control, critical area treatment, diversions and ditches, grade stabilization, pasture and range management, runoff and sediment control ponds and basins, stream bank and channel protection, and watershed, wildlife, and recreation land

improvement. These control measures are comparable to the USDA Soil Conservation Services' Resource Management Subsystem approach as referenced in AMBAG's "Water Quality Management Plan for the Monterey Bay Region," dated July 1978, and in ABAG's, "Handbook of Best Management Practices, “dated October 1977.

Experience has shown that no one control measure best solves an existing, or prevents a potential, pollution problem - especially in the area of soil erosion and sedimentation. As land use, the land user, and various situations change, so does the need for control measures. Before application, an on-site investigation with the land user is necessary to determine which practice or set of practices will be most effective and acceptable.

2. Erosion control should be implemented in a reasonable manner with as much implementation responsibility remaining with existing local entities and programs as is possible and consistent with water quality goals.

3. The Regional Board and local units of government should establish a clear policy for control of erosion, including consideration of off-site and cumulative impacts and the imposition of performance standards according to the sensitivity of the area where land is to be disturbed.

4. Effective ordinances and regulatory programs should be adopted by local units of government. Effective programs would allow only land disturbance actions consistent with the waste load capacity of the watershed, require preparation of erosion and sediment control plans with specific contents and with attention to both offsite/on-site impacts, identify performance standards, be at least comparable to the model ordinance in the "Erosion and Sediment Control Handbook," dated May 1978, and have provisions for inspection follow-up, enforcement, and referral.

5. Watersheds with critical erosion and sediment problems should be identified by one or more concerned agencies such as the California Department of Fish and Game, the Regional Board, the local Environmental Health, Planning, or Engineering Departments, the local Flood Control District, or the local Resource Conservation District, and then referred to the remaining agencies by a designated local coordinating agency for determining the scope, nature, and significance of the identified problem. The designated local agency would evaluate the adequacy and appropriateness of the total assessment, including an assessment of the problem and causes, alternatives considered, recommended interim and permanent control measures, and the amount and sources of funding. The evaluation would then be submitted as an Impact Findings Report for consideration and decision by the local governing body.

6. Comprehensive and continuous training should be mandatory for building and grading inspectors, engineers, and planners involved in approving, designing, or inspecting erosion control plans and on-site control measures. The training program would preferably be conducted on an inter-county/agency basis and be administered through a USDA Soil Conservation Service cooperative training arrangement or through seminars conducted by the USDA Soil Conservation Service and the University of California Cooperative Extension seminars. The Soil Conservation Society of America should be requested to assist in establishing an effective training program, including public education to heighten awareness of the adverse affects of erosion and sediment on soil and water resources.

7. More intensive erosion controls should be considered within four watersheds (Lauro Reservoir and Devereaux Ranch Slough in Santa Barbara County and Pismo Lake and Morro Bay in San Luis Obispo County) with apparent critical erosion and sediment problems. Alternative practices that may be implemented to effect the necessary level of control are assigned a relative priority.

VIII.E.1. LAND DISTURBANCE PROHIBITIONS

The discharge or threatened discharge of soil, silt, bark, slash, sawdust, or other organic and earthen materials into any stream in the basin in violation of best management practices for timber harvesting, construction, and other soil disturbance activities and in quantities deleterious to fish, wildlife, and other beneficial uses is prohibited.

The placing or disposal of soil, silt, bark, slash, sawdust, or other organic and earthen materials from timber harvesting, construction, and other soil disturbance activities at locations above the anticipated high water line of any stream in The basin where they may be washed into said waters by rainfall or runoff in quantities deleterious to fish, wildlife, and other beneficial uses is prohibited.

Soil disturbance activities not exempted pursuant to Regional Board Management Principles contained in Chapter Five are prohibited:

1. In geologically unstable areas,

2. On slopes in excess of thirty percent (excluding agricultural activities), and

3. On soils rated a severe erosion hazard by soil specialists (as recognized by the Executive Officer) where water quality may be adversely impacted;

Unless,

a. In the case of agriculture, operations comply with a Farm Conservation or Farm Management Plan approved by a Resource Conservation District or the USDA Soil Conservation Service;

b. In the case of construction and land development, an erosion and sediment control plan or its equivalent (e.g., EIR, local ordinance) prescribes best management practices to minimize erosion during the activity, and the plan is certified or approved, and will be enforced by a local unit of government through persons trained in erosion control techniques; or,

c. There is no threat to downstream beneficial uses of water, as certified by the Executive Officer of the Regional Board.

The controllable discharge of soil, silt, or earthen material from any grazing, farm animal and livestock, hydromodification, road, or other activity of whatever nature into waters of the State within the Pajaro River watershed is prohibited.

The controllable discharge of soil, silt, or earthen material from any grazing, farm animal and livestock, hydromodification, road, or other activity of whatever nature to a location where such material could pass into waters of the State within the Pajaro River watershed is prohibited.

The above two prohibitions do not apply to any discharge regulated by National Pollutant Discharge Elimination System permits, Waste Discharge Requirements or waivers of Waste Discharge Requirements.

The above two prohibitions do not apply to any grazing, farm animal and livestock, hydromodification, or road activity if the owner or operator:

i. Submits a Nonpoint Source Pollution Control Implementation Program, consistent with the *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program, May 20, 2004*, that is approved by the Executive Officer, or

ii. Demonstrates there is no activity that may cause soil, silt, or earthen material to pass into waters of the state within the Pajaro River watershed, as approved by the Executive Officer.

This Land Disturbance Prohibition takes effect three years following approval of the TMDL by the U.S. Environmental Protection Agency.

VIII.E.2. CONSTRUCTION ACTIVITIES

Road construction is often a cause of water quality impairment; all too often roads are located near streams, estuaries, or ocean waters where side fills may be eroded by flood waters. Construction within stream beds will inevitably cause turbidity; however, the timing of such activities should be established with reference to environmental sensitivity factors such as fish migrations, spawning or hatching, and

minimum stream flow conditions. Sediment loads can be reduced by proper timing, bank and channel protection, and use of settling ponds to catch silt.

Construction debris should not be left in the flood plain; revegetation of cuts and fills should be encouraged. California Department of Transportation (CALTRANS) has prepared a document entitled “Best Management Practices for Control of Water Pollution (Transportation Activities)," that sets forth procedures used by CALTRANS to address transportation activities which might impact water quality. These procedures are summarized under "Control Actions" in the Plans and Policies chapter. Past and potential impacts from CALTRANS activities may result from the above problems and may include impacts resulting from questionable maintenance practices, chemical spills, and discharges of silt and cement.

Land development projects in sensitive areas should be scheduled so as to minimize the areal extent of land exposed to erosive forces. Where water quality impairment is likely, permits should be issued by the Regional Water Quality Control Board which will insure against water quality degradation. Cooperation of local approving agencies should be obtained in order that approvals of significant subdivisions in environmentally sensitive areas, particularly the upper reaches of watersheds and lands near riparian habitats, are appropriately conditioned. For example, proposed subdivisions of 50 lots or more in such areas should be (1) covered by environmental impact reports on the development and its impact on waste loads and water quality, (2) be in conformance with regional or county master plans, and (3) include provisions for establishment of a public agency responsible for environmental monitoring and maintenance where such subdivisions are outside other appropriate public jurisdictions.

VIII.E.3. MINING ACTIVITIES

Pollution control at the hundreds of inactive mine sites riddling the Coast Ranges is in its infancy. Accurate regional inventories are being compiled, isolated mine cases are addressed individually, and several polluting mines are under direct regulation. Regional Board assistance and consultation are aiding several proactive responsible parties and focused study of inactive mine effects on four Central Coast watersheds has been funded by the Clean Water Act, Water Quality Planning Program.

About a decade ago Toxic Substances Monitoring Program data revealed elevated mercury concentrations in Lake Nacimiento, a high priority municipal and agricultural water storage reservoir in San Luis Obispo County. The Lake is fed by the Las Tablas Creek system (among others), which receives discharge water from the Buena Vista Mine, a mercury mine inactive since 1970 or 1971. An academic study (conducted by respected Cal Poly scientists -- team leader, Dr. Thomas J. Rice) of lake Nacimiento mercury sources recently concluded up to 78% of the fluvial mercury transport to the Lake is contributed by the Las Tablas Creek system. Further, the inactive Buena Vista and Klau Mines were identified as the primary point sources of Las Tablas Creek mercury. Based on these conclusions and other independent supporting data, the Regional Board on May 14, 1993, adopted four orders requiring strict implementation of NPDES surface water discharge standards and California Code of Regulations Title 23 mine waste management and mine closure standards at the Buena Vista Mine and the adjacent Klau Mine.

The U. S. Bureau of Land Management and Forest Service are addressing several inactive mercury mines on their properties pursuant to the federal "Superfund" process. Sample analyses data generated by Regional Board staff have been instrumental in aiding these investigations.

Two sequential studies of inactive mines in four watersheds of northwest San Luis Obispo County are underway. Funded partially by the Clean Water Act Water Quality Planning Program, the studies address all inactive mines in the Las Tablas Creek, Santa Rosa Creek, San Simeon Creek (all primarily mercury mines), and Chorro Creek (primarily chromium) watersheds. The primary goals of the watershed studies are:

- identification of all inactive mines
- attribution of specific water quality problems to specific mines, and
- determinations of the best methods of abating contaminant sources and remediating already emplaced surface contamination, based on field and possibly lab experiments.

These are considered pilot studies and the Regional Board ultimately plans to conduct such studies for the complete Region and to implement the findings, resulting in abatement of inactive mines as surface and ground water contaminant sources and remediation of contaminated media.

VIII.E.4. TIMBER HARVESTING ACTIVITIES

The Regional Board has regulatory responsibility to prevent adverse water quality impacts from timber harvest activities. Impacts usually consist of temperature, turbidity, and siltation effects caused by logging and associated activities. These can have deleterious impacts on fish and water flow.

Sensitivity of all watercourses, lakes, estuaries, or ocean waters in the basin to timber harvesting operations should be identified following rigorous analysis of geological, pedological, hydrological, and biological data as confirmed by field inspections. Relative sensitivity could then be portrayed on a large map. The sensitivity would also reflect beneficial uses which are not directly associated with ecological systems.

Upon receiving a timber harvest plan, the Regional Board staff could locate the operation on the sensitivity map and determine the relative risk involved. This information could enable the board to better evaluate the proposed method of operation and the adequacy of proposed mitigation actions or other special considerations. The success of this process depends upon the degree of cooperation provided by the Department of Forestry. Timber harvest plans must contain sufficient detail for evaluation, and the Regional Board must be allowed an ample amount of time for review before start of timber harvesting operations.

The timber yarding and road building methods used at each operation is a function of the terrain, soils, species and other timber considerations including economics. The aforementioned are usually compatible with water quality management, but in cases where water quality may be degraded, mitigating measures to preserve the character and quality of the water course must be taken. Since the Department of Forestry is familiar with the limitations and relative degradation potential of the various harvest methods, it has the lead role in incorporating necessary mitigation measures into the permits and seeing that they are enforced.

The Department of Forestry administers provisions of the Z'berg-Nejedly Forest Practice Act of 1973. The Act provides an opportunity for Regional Boards involved with timber harvesting activities to participate on the Timber Harvest Plan permit process review team. A 1987 Clean Water Act amendment requires States to implement Water Quality Management Plans to control nonpoint sources of pollution, including silviculture. As part of that directive, the State Board has executed a Management Agency Agreement (MAA) with the Board of Forestry and Department of Forestry. It provides a better opportunity for water quality concerns to be incorporated into timber harvesting practices and regulations.

Several possibilities exist to deal with negligent or incompetent operators. The Department of Forestry can revoke the Registered Professional Foresters or Licensed Timber Operator's License. The Regional Board can also implement enforcement action. While these actions can be necessary and effective, they are after-the-fact methods rather than for deterring roles. Thus, the major emphasis must be placed on control measures rather than enforcement actions.

VIII.E.5. AGENCY ACTIVITIES

To insure that impacts on water quality from nonpoint sources of pollution are held to a minimum and that goals and management principles of the Regional Board are met, water quality management programs for implementation by land managing agencies have been developed through the Area wide planning process. For nonpoint sources of pollution, this required identification of Best Management Practices (BMP's).

Within the Central Coast Region, federal and State agencies control substantial portions of land. All retain their own land management programs, but are required by regulation to cooperate and give support to State planning agencies in formulating and implementing water quality management plans. Federal law also directs federal agencies to comply with requirements formulated to meet the objectives of the federal act.

Practices and procedures in the U. S. Forest Service's, U.S. Bureau of Land Management's (BLM's) and California Department of Transportation's (CALTRANS') 208 reports described below constitute proper management for water quality protection and are considered BMP's. Further, these agencies have expressed a willingness and capability to implement practices and to revise practices which are currently inadequate. Management agency agreements have been prepared between the State Board and each of these agencies which designates the Forest Service, the BLM, and CALTRANS as management agencies

responsible for implementing BMPs for water quality protection on lands under the control of each of these respective agencies. The management agency agreement further provides for State/Regional Board working relationships with each agency and establishes a mechanism by which the State and Regional Boards will, on a continuing basis and in conjunction with each of these agencies, identify and address water quality management issues of concern to all parties.

The management agency agreements, as approved by the State Water Resources Control Board and each of the agencies, are a part of this Water Quality Control Plan by reference. Management agency agreements will be reviewed and updated periodically to reflect recent achievements, new information, and new concerns.

VIII.E.5.a. UNITED STATES FOREST SERVICE

The United States Forest Service has prepared a report entitled, "Water Quality Management Plan for the National Forest Systems Lands Within the Non-designated Planning Areas of California," dated April, 1979. The report assesses water quality problems, evaluates current practices, and sets forth procedures used by the Forest Service to address activities that might affect water quality. About 72 percent of Los Padres National Forest (which encompasses 1,964,408 gross acres) is within the Central Coast Region. Water and watershed protection were the chief reasons the forest was established. Approximately 1.5 million acre feet of water per year are used by people living adjacent to the forest for domestic and agricultural purposes. Less than five percent of the area is commercial forest land and most wood production is fuel wood sales.

A qualitative assessment of water quality problems on National Forest lands within the Central Coast Region was conducted primarily from information gathered by Forest Service and Regional Board staff. Fire management and recreation are activities with the greatest influence on water quality. Other major activities with potential impact on water quality include road construction, road maintenance, and grazing. Fire management can cause degradation from sediments, nutrients, and bacteria, but the major cause might well be off-road vehicles and misuse of unimproved roads by all vehicles. Road construction has been a source of problems along the Cuyama River. No significant affects from overgrazing or silvacultural practices were noted.

During preparation of the Forest Service's "Water Quality Management Plan for the National Forest Systems Lands Within the Nondesignated Planning Area of California," adopted April, 1979, Forest Service manuals, guidelines, regulations, etc., were reviewed for identification of those practices which are directly or indirectly for the purpose of protecting water quality. The report identifies and discusses ninety-eight such practices in eight activity categories (i.e., timber harvesting, road and building site construction, mining, recreation, vegetative manipulation, fire supervision and prescribed burning, watershed management, and grazing). Ninety-four of the practices are presented as BMPs, while four practices need improvement, and four practices need development. A course of action for improving inadequacies of current practices and for development of new practices is identified.

The practices/procedures contained in the Forest Service 208 plan are at a level of detail appropriate for all Forest Service operations statewide. These practices must be flexible to account for varying geographic conditions. The plan also includes a description of the "decision- making" process which leads to the actual selections of management solutions on a project-specific basis. There are several steps in this process at which Regional Boards can be involved and there is a public involvement program to identify and respond to concerns of interested public. The most critical point of involvement is Step 1, identification of issues, concerns, and opportunities. Once this step is completed, the need for and time of future involvement in subsequent steps can be identified.

VIII.E.5.b. UNITED STATES BUREAU OF LAND MANAGEMENT

The United States Department of the Interior, Bureau of Land Management (BLM), has management responsibility for approximately 320,000 acres within the Central Coast Region. Management

activities occurring on this land have potential for significantly affecting water quality (e.g., mining, grazing, recreation, road construction, off-road vehicles, etc.). The BLM prepared and submitted to the State a report entitled, "BLM California 208 Report." The report includes: (a) a discussion of existing or potential water quality problems on BLM lands, (b) a discussion of current BLM practices and policies including a description of the BLM planning process, (c) a description of the "decision-making process" which leads to the actual selection of management solutions on a project-specific basis, and (d) general policies.

The problem assessment identifies nonpoint sources of water pollution originating on lands administered by the BLM. Problems were qualitatively assessed by BLM with information provided primarily by Regional Board staff. Most of the identified water quality problems on BLM lands within the Central Coast Region result from recreation.

There is improper grazing management on the Temblor range in east San Luis Obispo County (BLM's Bakersfield District) that is causing sedimentation of retention structures for beneficial uses.

The process for determining management practices on a site- specific basis applies to all BLM activities and is divided into three major phases; (1) consideration of site characteristics and water quality concerns, (2) definition and application of BMP's through contract clauses, leases, stipulations, etc., and (3) evaluation of BMP effectiveness and practice modification, if necessary.

VIII.E.5.c. CALIFORNIA DEPARTMENT OF TRANSPORTATION

WATER QUALITY STUDIES

In developing control measures for CALTRANS projects, three basic types of studies are conducted for water quality protection:

1. Transportation System Planning - Emphasizes broad scale water quality problems. The focus is on regional factors such as variations in regional surface and ground water hydrology, existing water quality, and land use. Such studies are not site- specific.

2. Project Level Planning - Emphasis is on runoff associated problems (erosion and sedimentation). Detailed hydrologic and hydraulic analyses are made where warranted. Information is used in selecting project alternatives.

3. Construction - This type is usually associated with waste discharge requirements (issued by Regional Board). The intent is to monitor and control the contractor's operations.

CONSTRUCTION CONTROL

Standard specifications for water pollution control have been prepared by CALTRANS, are set forth in CALTRANS' BMP document, and are incorporated as part of project design. Where warranted, special specifications are prepared by CALTRANS on a project- by-project basis. For every project, contractors must submit a plan for water pollution control to the CALTRANS resident engineer. During the course of any construction project, operations may be temporarily halted if inadequate provision has been made for water quality protection. Remedial work may be required.

In addition to CALTRANS specifications, federal and State permits (including waste discharge requirements) are made a part of project requirements.

OPERATION AND MAINTENANCE

1. Accidental Chemical Spills - A procedural manual has been developed by each CALTRANS district to standardize cleanup procedures. CALTRANS maintenance personnel are equipped and trained to handle such situations.

2. Erosion Control - Where slopes show evidence of erosion, remedial stabilization measures must be taken. Debris is disposed of at approved disposal site.

VIII.E.5.d. OTHER AGENCIES PROGRAMS

Resource Conservation Districts (RCD's) and the U.S.D.A. Soil Conservation Service are organizations that assist property owners in applying effective conservation and land management practices. The program includes technical, educational, and planning services to property owners and local governments who request assistance. It has been relatively successful considering its voluntary nature and resource limitations. The Soil Conservation Service has a major role in the Rural Clean Water Program.

The U.S.D.A. Agricultural Stabilization and Conservation Service administers the cost-sharing aspects of the Agricultural Conservation Program, allocating available monies to farmers and ranchers for erosion and sedimentation control and water conservation projects.

Cities and Counties, as general purpose governments, have broad powers to adopt specific and general plans; to regulate land use, subdividing, grading, and private construction; and to construct and operate public works facilities. Local authority to regulate existing and potential discharges of sediment has been exercised to varying degrees throughout the region.

Many cities and counties within the coastal zone have developed Local Coastal Programs. These programs may include land use and grading restrictions designed to protect long-term productivity of soils and waters within the coastal zone. Regulation by the California Coastal Commission provides this protection where Local Coastal Programs are inadequate.

The State Department of Fish and Game promotes the protection and improvement of streams, lakes, and natural habitat areas for fish and wildlife. It also regulates stream alteration and compels cleanup of fouled streams.

VIII.E.6. WATSONVILLE SLOUGH WATERSHED LIVESTOCK WASTE DISCHARGE PROHIBITION

1. The direct or indirect discharge of livestock animal waste from any grazing operations, non-sterile manure application, farm animal and livestock facilities including paddocks, pens, corrals, barns, sheds, or other activity of whatever nature into waters of the State within the Watsonville Slough Watershed is prohibited.

   The above prohibition does not apply to any farm animal or livestock facility and/or any facility where non-sterile manure is applied if the owner or operator:

   i. Submits a Nonpoint Source Pollution Control Implementation Program, consistent with the *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program*, that is approved by the Executive Officer, or

   ii. Demonstrates to the satisfaction of the Executive Officer that its activities do not cause livestock waste to pass into waters of the state within the Watsonville Slough Watershed, or

   iii. Is regulated under Waste Discharge Requirements or an NPDES permit, or a conditional waiver of waste discharge requirements that explicitly addresses compliance with the Watsonville Slough TMDL for Pathogens.

This Livestock Waste Discharge Prohibition takes effect two years following approval of the TMDL by the U.S. Environmental Protection Agency.

IX. TOTAL MAXIMUM DAILY LOADS

IX. A. MORRO BAY TOTAL MAXIMUM DAILY LOAD FOR SEDIMENT (INCLUDING CHORRO CREEK, LOS OSOS CREEK AND THE MORRO BAY ESTUARY)

This TMDL was adopted by the Regional Water Quality Control Board on May 16, 2003.
This TMDL was approved by:
The State Water Resources Control Board on September 16, 2003.
The California Office of Administrative Law on December 3, 2003 (effective date).
The U.S. Environmental Protection Agency on January 20, 2004.

TMDL ELEMENTS

Element	
Problem Statement	Over time, all estuaries eventually fill with sediment due to the natural processes of erosion and sedimentation. In Morro Bay these natural processes have been accelerated due to anthropogenic watershed disturbances, resulting in impairment of Beneficial Uses, principally biological resources, but also recreational uses, including: RARE, MIGR, SPWN, WILD, EST, MAR, BIOL, REC1, REC2, NAV. This impairment indicates an exceedance of the Basin Plan narrative objective for sediment, which states that: “the suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.”

Numeric Targets	Parameter	Numeric Target
	Chorro and Los Osos Creeks and Tributaries Streambed Sediment	
	Residual Pool Volume[1]	V* (a ratio) = Mean values ≤ 0.21 (mean of at least 6 pools per sampling reach) Max values ≤ 0.45
	Median Diameter (D_{50}) of Sediment Particles in Spawning Gravels	D_{50} = Mean values ≥ 69 mm Minimum values ≥ 37 mm
	Percent of Fine Fines (< 0.85 mm) in Spawning Gravels	Percent fine fines ≤ 21%
	Percent of Coarse Fines (all fines < 6.0 mm) in Spawning Gravels	Percent coarse fines ≤ 30%
	Morro Bay and Estuary	
	Tidal Prism Volume	4,200 acre-feet

Loading Allocations[2] (TMDL expressed as annual load)	Watershed	Total (tons/year, rounded to nearest ton)
	Chorro Creek at Reservoir	6,541
	Dairy Creek	440
	Pennington Creek	966
	San Luisito Creek	7,315
	San Bernardo Creek	10,270
	Minor Tributaries	4,489
	Chorro Creek	30,021
	Los Osos Creek	3,052
	Warden Creek and Tributaries	1,812
	Los Osos Creek	4,864
	Morro Bay Watershed	34,885

1 Residual Pool Volume refers to the portion of a pool in a stream that is available for fish to occupy. Pool habitat is the primary habitat for steelhead in summer. Overwintering habitat requirements include deeper pools, undercut banks, side channels, and especially large, unembedded rocks, which provide shelter for fish against the high flows of winter. V* gives a direct measurement of the impact of sediment on pool volume. It is the ratio of the amount of pool volume filled in with fine, mobile sediment, to total scour pool volume. Qualifying pools are those having a gradient less than 5%, a minimum depth twice the riffle-crest depth, a fairly even spacing between tributaries, and are located on streams fifth order or smaller.

2 These loading allocations are 50% of the estimated current sediment loading to Morro bay.

Implementation	The sediment load to Morro Bay, Los Osos Creek and Chorro Creek derives from nonpoint sources (NPS) and point sources. As such, implementation will rely on the State's Plan for NPS pollution control (CWC §13369) and continued implementation of existing regulatory controls as appropriate for point sources, including storm water pursuant to NPDES surface water discharge regulations and Waste Discharge Requirements (Porter Cologne). At this time, implementation emphasizes the activities of the Morro Bay National Estuary Program, Coastal San Luis Resources Conservation District, and other public and private groups that are not currently identified as dischargers responsible for sediment loading, to implement self-determined activities (see Table: Trackable Implementation Actions). Other actions, currently required because of another program, will be evaluated to make sure progress is taking place (see Table: Trackable Implementation Actions identifying Responsible Dischargers). Regional Board Staff will meet annually with the implementing parties identified in the list of Trackable Implementation Actions to provide technical assistance and to evaluate and track progress (see Implementation Schedule for details). If at the end of year three, implementing parties fail to complete these self-determined activities or resulting management practices fail to reduce sediment loads, then Regional Board staff may conduct inspections and investigations to identify individual responsible dischargers (e.g., landowners or public agencies). Regional Board staff may rely on Section 13267 of the California Water Code or other appropriate authorities for investigation and identification of individual responsible dischargers. Regional Board staff will also rely on Section 13267 of the California Water Code to require reporting and/or monitoring to determine the level of implementation of identified activities to reduce erosion and sediment. If necessary, the Regional Board may rely on enforcement authority, pursuant to California Water Code Section 13304, to require dischargers to clean-up and abate sediment discharges and/or prevent the threat of discharges on a case-by case basis. Additionally, Implementation Actions (in the Table of Implementation Actions) may be required as conditions of compliance with storm water permits and Waste Discharge Requirements. If at the end of the third year, self-determined actions have not been completed, staff will develop a regulatory approach (rather than a self-determined approach) and present a revised implementation plan to the Regional Board as a Basin Plan Amendment. Direct measurement of sediment loading is not proposed for this TMDL. Numeric Targets, which characterize the effect of loading are to be measured in lieu of loadings. The 50-year schedule for achieving the TMDL acknowledges that implementation actions taken in the near term are expected to take years to produce a response as measured through Numeric Target monitoring. Allocations will achieve the targets because over the long term, these allocated sediment loads are expected to result in changes in sediment distributions in the channel and the estuary that meet water quality objectives. Numeric targets and other parameters will be monitored to ensure that numeric targets are met. The Regional Board will rely on existing or planned efforts for this monitoring (e.g., Morro Bay National Estuary Program, Central Coast Ambient Monitoring Program).
Margin of Safety	An implicit margin of safety has been incorporated into this TMDL through the use of conservative assumptions throughout the source analysis and characterization of beneficial use impacts. The margin of safety is required due to uncertainty in calculations of sediment loading and of the effects of this loading on beneficial uses of the Morro Bay Estuary, Chorro Creek and Los Osos Creek.

Trackable Implementation Actions

PROJECT NAME		ACTION	SCHEDULE	IMPLEMENTING PARTY
1	Hollister Ranch Acquisition	Design and construct floodplain restoration project	January 2002-May 2005	CSLRCD and MBNEP
2	Los Osos Creek Wetland Restoration Project	Design and construct Los Osos Creek wetland restoration project	Fall 2000-Spring 2004	CSLRCD and MBNEP
3	Watershed Crew Curriculum	Develop a curriculum that will provide training for a year-round crew of Civilian Conservation Corps	Winter 2001-Fall 2001	CCC
4	Catalogue of Erosion Control Projects	Develop a list of areas in need of erosion control projects	Spring 2001-Fall 2001; on-going	MBNEP
5	Project Clearwater	Provide technical assistance and cost sharing to install BMPs	2001-June 2004; on-going	CSLRCD
6	Agricultural Water Quality Program	Develop and implement a voluntary, cost-effective, and landowner/manager-directed program	2001-2002; on-going	Farm Bureau
7	Land Acquisitions and Conservation Easements	Acquire or otherwise protect lands in cooperation with willing land owners	2000-2010; on-going	MBNEP
8	Fire Management Plan	Develop and implement a Fire Management Plan	2001-2006; on-going	CDF
9	Maintenance of Sediment Basins Above Chorro Reservoir	Continue maintenance of the sediment basins above Chorro Reservoir	on-going	California Army National Guard
10	Road Maintenance	Increase the use of management measures for road maintenance and construction	2001-2006; on-going	County of San Luis Obispo, Public and Private Landowners; California Department of Transportation
11	Sediment Traps	Install sediment traps	2000-2007; on-going	CSLRCD; Natural Resource Conservation Service; DFG; Public and Private Land Owners
PROJECT NAME		ACTION	SCHEDULE	RESPONSIBLE DISCHARGERS
12	Primera Mine Rehabilitation and Erosion Control	Remediation of Primera Mine	2003	California Army National Guard
13	Stormwater Sediment Control on Roads	Include specific road sediment control measures in County stormwater management plan prior to enrollment in Stormwater Permit; track implementation of BMPs	Prior to March 2003; on-going	County of San Luis Obispo
14		Track implementation of BMPs in Stormwater Permit	On-going	Caltrans
15	Water Quality Management Plans on Chorro Creek Ranches	Implement Waste Discharge Requirements to address Chorro Creek Ranches	Fall 2002-Fall 2003	California Polytechnic State University

Implementation Schedule

At End of Implementation Year:	IMPLEMENTATION MILESTONE			MONITORING ACTIVITY		
	Chorro Creek	*Los Osos Creek*	*Morro Bay*	*Chorro Creek*	*Los Osos Creek*	*Morro Bay*
1	RB and MBNEP Staff meet to review progress. RB and County Staff meet to review inclusion of road erosion control measures in Stormwater Management Plan.			Baseline Streambed Parameters3, Turbidity		
2	*As above*					
3	RB and MBNEP Staff meet to review progress; RB requests implementation tracking report from Implementing Parties if not provided; RB staff consider modifications to Trackable Implementation Actions			Baseline Streambed Parameters, Turbidity		
4	RB and MBNEP Staff meet to review progress			Baseline Streambed Parameters, Turbidity		
5	RB and MBNEP Staff meet to review progress		RB Staff calculate: 5-year changes to Bay area and volume	Baseline Streambed Parameters, Turbidity		Bathymetry survey
6	RB and MBNEP Staff meet to review progress; RB request implementation tracking report from Implementing Parties if not provided; RB staff consider modifications to Trackable Implementation Actions			Baseline Streambed Parameters, Turbidity		
7	RB and MBNEP Staff meet to review progress			Baseline Streambed Parameters, Turbidity		
8	*As above*					
9	RB and MBNEP Staff meet to review progress; RB request implementation tracking report from Implementing Parties if not provided; RB staff consider modifications to Trackable Implementation Actions			Baseline Streambed Parameters, Turbidity		
10	RB and MBNEP Staff meet to review progress; RB Staff calculate 10-year rolling average of Streambed Sediment data		RB Staff calculate: 5-year changes to Bay area and volume	Baseline Streambed Parameters, Turbidity		Bathymetry survey
11	RB and MBNEP Staff meet to review progress; RB Staff calculate 10-year rolling average of Streambed Sediment data			Streambed Parameters, Turbidity		
12	RB and MBNEP Staff meet to review progress; RB Staff calculate 10-year rolling average of Streambed Sediment data; RB request implementation tracking report from Implementing Parties if not provided; RB staff consider modifications to Trackable Implementation Actions			Streambed Parameters, Turbidity		
13	RB and MBNEP Staff meet to review progress; RB Staff calculates 10-year rolling average of Streambed Sediment data			Streambed Parameters, Turbidity		
14	As above					

3 Streambed Parameters, which are the Numeric Targets, include Residual Pool Volume, Median Diameter of Sediment Particles, Percent Fine Sediment, and Percent Coarse Sediment.

At End of Implementation Year:	IMPLEMENTATION MILESTONE		MONITORING ACTIVITY	
15	RB and MBNEP Staff meet to review progress; RB Staff calculate 10-year rolling average of Streambed Sediment data; RB request implementation tracking report from Implementing Parties if not provided; RB staff consider modifications to Trackable Implementation Actions	RB Staff calculate: 5-year changes to Bay area and volume	Streambed Parameters Turbidity	Bathymetry survey
16-49	Repeat as above with 3-, 5- and 10-year milestones.			
50	Numeric targets achieved; load reduction achieved			

IX. B. SAN LORENZO RIVER TOTAL MAXIMUM DAILY LOAD FOR SEDIMENT (INCLUDING CARBONERA CREEK, LOMPICO CREEK, AND SHINGLE MILL CREEK)

This TMDL was adopted by the Regional Water Quality Control Board on May 16, 2003.
This TMDL was approved by:
The State Water Resources Control Board on September 16, 2003.
The California Office of Administrative Law on December 18, 2003.
The U.S. Environmental Protection Agency on February 19, 2004.

TMDL ELEMENTS

Problem Statement:
The natural processes of erosion and sedimentation in the San Lorenzo River Watershed have been accelerated due to anthropogenic watershed disturbances. Studies conducted by various authors have concluded that erosion rates were two to four times natural rates. These studies have also documented and quantified the decline in anadromous fisheries and the quality of fish habitat. Excessive Sedimentation has interfered with the beneficial uses of these waterbodies including, Fish and Wildlife (RARE, MIGR, SPWN, WILD).

Numeric Targets (interpretation of the narrative water quality objectives for settleable solids and sediment):
Because the sediment objectives in the Basin Plan are narrative, rather than numeric, this Basin Plan amendment establishes numeric targets as indicators of water quality that are supportive of beneficial uses. The numeric targets serve to interpret the narrative water quality objectives and provide a measure with which to determine if the objectives and the TMDL are being met. The combination of these parameters is considered an effective approach in lieu of directly measuring sediment loading to the listed waterbodies. Attainment of Numeric Targets will be measured over a ten-year rolling time period. Numeric targets for the listed waterbodies and compliance points on tributaries are as follows:

Parameter	Numeric Target[1]
Residual Pool Volume[2]	V* = Mean values $\leq$ 0.21 Max values $\leq$ 0.45
Median Diameter (D_{50}) of Sediment Particles in Spawning Gravels	D_{50} = Mean values $\geq$69 mm Minimum values $\geq$ 37 mm
Percent of Fine Fines (< 0.85 mm) in Spawning Gravels	Percent fine fines $\leq$ 21%
Percent of Coarse Fines (< 6.0 mm) in Spawning Gravels	Percent coarse fines $\leq$ 30%

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1 Target values are for sampling reach(es) within an individual waterbody.

2 Residual Pool Volume refers to the portion of a pool in a stream that is available for fish to occupy. Pool habitat is the primary habitat for steelhead in summer. Overwintering habitat requirements include deeper pools, undercut banks, side channels, and especially large, unembedded rocks, which provide shelter for fish against the high flows of winter. V* gives a direct measurement of the impact of sediment on pool volume. It is the ratio of the amount of *pool volume filled by fine, mobile sediment*, to *total pool volume*. Qualifying pools are those having a gradient less than 5%, a minimum depth twice the riffle-crest depth, a fairly even spacing between tributaries, and are located on streams fifth order or smaller.

Total Maximum Daily Load and Load Allocations

The Total Maximum Daily Load (expressed here as an annual load) was based on reductions necessary to achieve desired conditions of streambed sediment parameters (embeddedness and fraction of sediment particles less than 4mm in diameter). Desired conditions taken from values published in the scientific literature were 27% lower on average for the San Lorenzo River, Carbonera Creek and Shingle Mill Creek, and 24% lower on Lompico Creek, than measured values in these waterbodies, respectively. Load allocations were based on percent attainable reductions in each sediment source category.

Natural background sediment load was not calculated as a separate allocation of the TMDL. The Mass Wasting and Channel/Bank Erosion categories account for natural and anthropogenic loads associated with these processes. The load from Timber Harvest Plan Roads, Public/Private Roads, Timber Harvest Plan Lands and Other Urban and Rural Lands is assumed to be entirely anthropogenically derived and controllable.

Sediment Source Category	Allocations (tons/year)			
	Shingle Mill Creek	Carbonera Creek	Lompico Creek	San Lorenzo River
Upland Timber Harvest Plan (THP) Roads	0	420	362	25,215
Streamside THP Roads on Steep Slopes	0	182	164	10,949
Upland Public/Private Roads	146	1,233	367	13,835
Streamside Public/Private Roads on Steep Slopes	77	135	239	6,178
THP Land	0	23	16	1,057
Other Urban and Rural Land	310	2,622	965	43,368
Mass Wasting	0	4,082	6,440	157,388
Channel/Bank Erosion	324	3,030	989	48,149
Total Allocation = TMDL[3]	857	11,728	9,542	306,139

Implementation Plan

The sediment load to the San Lorenzo River, Lompico Creek, Carbonera Creek, and Shingle Mill Creek derives from nonpoint sources (NPS) and point sources. As such, implementation to achieve the TMDL will rely on the State's Plan for NPS pollution control (CWC §13369) and on existing and anticipated independent regulatory programs for regulated storm water discharges.

At this time implementation emphasizes the activities of the Santa Cruz County Departments of Planning and Public Works, the Santa Cruz County Resource Conservation District, and other public and private groups, not currently identified as dischargers responsible for causing erosion, to implement self-determined activities (Implementation Actions C through R, see following list, Trackable Implementation Actions). Regional Board staff will meet annually with these "Implementing Parties" identified in the list of Trackable Implementation Actions to provide technical assistance, and to evaluate and track progress (See following Implementation Compliance Schedule).

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3 The term "Total Maximum Daily Load" or "TMDL" is used here for familiarity. The allowable loads for the San Lorenzo River and its tributaries are actually expressed as a Total Annual Loads (tons/year). This expression of load accounts for seasonal variation in sediment loads explained by the seasonality of rainfall in this region of the Central Coast.

By the end of the first year of implementation, the Regional Board and the implementing parties will establish a time schedule for completion of Trackable Implementation Actions C through R. If these entities fail to complete these Tier 1, self-determined activities or resulting management practices to reduce sedimentation per the time schedule established, Regional Board staff intends to conduct inspections and investigations to identify individual responsible dischargers (e.g., landowners or regulated public agencies). Regional Board staff may rely on Section 13267 of the California Water Code for investigation and identification of individual responsible dischargers. Regional Board staff will also rely on Section 13267 of the California Water Code to require reporting and/or monitoring to determine the level of implementation of management practices to reduce sedimentation. If necessary, the Regional Board may rely on enforcement authority, pursuant to California Water Code Section 13304, to require dischargers to clean up and abate sediment discharges and/or prevent the threat of discharges. The Implementation Actions identified in this Implementation Plan do not identify the specific management practices that will result in sediment reduction. As such the management practices developed through pursuit of the Implementation Actions are not intended to be independently enforceable by the Regional Board. Therefore, the Regional Board will rely on scheduled 3-year reviews to track Implementation Actions and the effectiveness of management practices to determine whether to continue with Tier 1, self-determined implementation. This portion of the implementation program currently relies on voluntary compliance and so is not regulatory. If, in future years, evaluation of progress indicates regulatory mechanisms are needed to implement actions that will result in attainment of the numeric targets, this will be achieved on a case-by-case basis using existing authority or if necessary, by amending the TMDL implementation program through a Basin Plan amendment.

To regulate sediment discharges derived from regulated storm water discharges, implementation relies on National Pollutant Discharge Elimination System (NPDES) general permits covering municipalities and construction activities anticipated to be in place by March 2003. Implementation Actions S, T and U (see following list, Trackable Implementation Actions) identify actions that will be required of entities enrolling in these general permits. These entities are identified as “Responsible Dischargers” on this list. These actions will be required pursuant to the terms of the general permits, so this portion of the implementation program also does not impose any new regulatory requirements. To the extent the discharge is addressed by a Storm Water Permit, the Regional Board anticipates that management practices developed from any of the Implementation Actions (in the list of Trackable Implementation Actions) will be included in Storm Water Management Plans and Storm Water Pollution Prevention Plans. If the management practices are not included in these Plans, the Regional Board will work with dischargers to condition the Plans on an individual basis, will consider issuing individual Storm Water permits or waste discharge requirements, and/or, if necessary take actions to enforce the terms of the permits or waste discharge requirements. The Regional Board will take any such actions on a case-by-case basis using existing authority or if necessary, by amendment of the TMDL implementation program.

Margin of Safety

A margin of safety has been established implicitly in the TMDL calculation through conservative assumptions used in establishing the percent reduction from existing loads necessary to protect beneficial uses.

Monitoring

The TMDL will be evaluated by monitoring the four numeric targets specified above, as well as by tracking progress in implementation of voluntary and required implementation actions. Responsibility for tracking, reporting status, and evaluating the effectiveness of voluntary implementation actions, is shared by the Regional Board and participating members of the San Lorenzo River Technical Advisory Committee. Initially the Regional Board will be responsible for monitoring numeric targets. Any monitoring undertaken by members of the Committee, including turbidity monitoring by the San Lorenzo Valley Water District and the City of Santa Cruz Water Agency, as well as “comprehensive” monitoring of parameters affecting cold water fisheries conducted by various agencies, will be on a voluntary basis. Monitoring efforts pursuant to existing or anticipated regulatory programs or other voluntary efforts will be evaluated along with monitoring for numeric targets. The Board will evaluate progress on implementation actions in consultation with the San Lorenzo River Technical Advisory Committee. As more information is obtained concerning sources, locations and rates of sedimentation, TMDL numeric targets and implementation projects may be amended or modified through an amendment to the Basin Plan, as appropriate.

Trackable Implementation Actions to Address Sources of Erosion and Sedimentation

Source Category	Implementation Action	Implementing Party
Roads: Upland and Streamside Timber Harvest Plans	A Increase presence at Pre-Harvest Inspections to 100% of Class I and Class II watercourses (watercourses supporting use for domestic water supply, fish, and/or aquatic habitat for non-fish aquatic species).	Regional Water Quality Control Board (RWQCB)
	B Perform Post-Harvest Inspections 3 to 5 years after harvest on Timber Harvest Plans with Class I and Class II watercourse crossings.	RWQCB
	C Convene a Working Group of federal, state, and local agencies, and timberland owners and foresters to develop specific timber harvesting management practices for the San Lorenzo River Watershed.	National Marine Fisheries Service (NMFS), California Department of Forestry and Fire Protection (CDF), Santa Cruz County (County) Planning, RWQCB, Timber Owners and Foresters
	D Enforce erosion control ordinance following 3-year Timber Harvest Plan maintenance period.	County Planning
	E Develop strategy for more effective enforcement of County code violations pertaining to erosion control and sedimentation prevention throughout the San Lorenzo Watershed.	County Planning
	F RWQCB will review evidence of Timber Harvest Plan Best Management Practices developed pursuant to Section 916.9 of 2001 Forest Practices Act during Pre-Harvest and Post-Harvest Inspections.	CDF, Timber Harvest Plan Submitter, RWQCB
Roads: Upland and Streamside Public/Private	E See above	
	G Create public road database to inventory and prioritize problems for correction.	County Public Works, Caltrans, Cities of Santa Cruz and Scotts Valley
	H Develop a Public Road Maintenance Best Management Practices (BMP) Program.	County Public Works and Planning
	I Improve public road spoils management and disposal: develop spoils disposal site(s) in or near the San Lorenzo Watershed.	County Public Works and Caltrans
	J Assess State Park roads and trails for erosion into San Lorenzo River and tributaries. Develop a program for funding and addressing any identified problems.	California Department of Parks and Recreation
	K Develop and implement private road improvement program.	Santa Cruz Resource Conservation District (RCD)-lead, Natural Resources Conservation Service, County Department of Environmental Health, RWQCB, California Department of Fish and Game, landowners
Developed Parcels: THP Lands	A-F See above	
	E See above	

Source Category	Implementation Action		Implementing Party
Developed Parcels: Other Urban and Rural Land	L	Evaluate need to revise erosion control provisions in County Grading Regulations and Erosion Control Ordinance to better protect sandy-soil areas.	County Planning
	M	Evaluate need to revise erosion control provisions in City of Scotts Valley Grading Regulations and Erosion Control Ordinance to better protect sandy-soil areas.	City of Scotts Valley
	N	Evaluate need to revise erosion control provisions in City of Santa Cruz Grading Regulations and Erosion Control Ordinance to better protect sandy-soil areas.	City of Santa Cruz
	O	Promote improved livestock management practices to reduce discharge of sediment.	RCD, Santa Cruz Horsemen, County Planning, County Environmental Health Services, Livestock Owners
	P	Implement education programs and modify policies and procedures to improve riparian corridor protection, maintain channel integrity, implement alternatives to hard bank protection, and retain woody material.	County Planning, DFG, Cities
Mass Wasting	Q	Develop strategy to reduce erosion from discrete sources, including Mount Hermon slide, Bean Creek Road slides, McEnery Road, Skypark, Rancho Rio and Monte Fiore.	County, City of Scotts Valley
	R	Develop strategy to address accelerating the mitigation of quarry impacts at Hanson Aggregates site.	County Planning, California Division of Mines and Geology
Streambanks	A-H, J-N, P *See above*		
Source Category	Implementation Action		Responsible Dischargers
All Roads, Developed, and Developing Parcels	S	Develop and implement Storm Water Management Plans (SWMPs) and Storm Water Pollution Prevention Plans (SWPPPs) consistent with NPDES Phase II Storm Water regulations.	County Planning and Public Works, City of Santa Cruz, City of Scotts Valley, construction site operators and owners.
	T	Identify the San Lorenzo River Watershed as a priority for site inspection and enforcement of control measures in SWMPs and SWPPPs. Establish mechanism by which operators and owners of one-acre and greater construction projects are notified of the requirement to prepare SWPPPs.	County Planning and Public Works, City of Santa Cruz, City of Scotts Valley, construction site operators and owners.
	U	Consider incorporation of sediment control programs/projects into SWMPs and SWPPPs.	County Planning and Public Works, City of Santa Cruz, City of Scotts Valley, construction site operators and owners.

Implementation Compliance Schedule

At End of Implementation Year:	IMPLEMENTATION MILESTONE	MONITORING ACTIVITY[4]
	San Lorenzo River Mainstem and Tributaries	***San Lorenzo River Mainstem and Tributaries***
1	Regional Board (RB) staff and San Lorenzo River Technical Advisory Committee (SLR TAC) meet to: a) review progress on implementation actions; b) adopt Comprehensive Monitoring Program; and c) establish time schedules for Implementation Actions. RB and County staff meet to review inclusion of high priority status of San Lorenzo Watershed in Stormwater Management Plan.	Refine sampling strategy for comprehensive monitoring plan; Turbidity by water agencies.
2	RB staff and SLR TAC meet to review progress on implementation actions and monitoring.	Full suite of Numeric Target Parameters at compliance points; Turbidity by water agencies.
3	Implementing Parties submit report on progress of actions; RB staff and SLR TAC meet to review progress on implementation actions and monitoring; RB staff consider modifications to Trackable Implementation Actions; RB requests implementation tracking report from Implementing Parties if not provided;	Turbidity by water agencies.
4	RB staff and SLR TAC meet to review progress on implementation actions;	Turbidity by water agencies.
5	RB staff and SLR TAC meet to review progress on implementation actions;	Full suite of Numeric Target Parameters at compliance points; Turbidity by water agencies.
6	Implementing Parties submit report on progress of actions; RB staff and SLR TAC meet to review progress on implementation actions and monitoring; RB staff consider modifications to Trackable Implementation Actions; RB requests implementation tracking report from Implementing Parties if not provided;	Turbidity by water agencies.
7	RB staff and SLR TAC meet to review progress on implementation actions;	Turbidity by water agencies.
8	RB staff and SLR TAC meet to review progress on implementation actions;	Full suite on compliance points; Turbidity by water agencies.
9	Implementing Parties submit report on progress of actions; RB staff and SLR TAC meet to review progress on implementation actions and monitoring; RB staff consider modifications to Trackable Implementation Actions; RB requests implementation tracking report from Implementing Parties if not provided;	Turbidity by water agencies.
10	RB staff and SLR TAC meet to review progress on implementation actions;	Turbidity by water agencies.
11	RB staff and SLR TAC meet to review progress on implementation actions; RB staff calculate 10-year rolling average of streambed sediment data and turbidity;	Full suite of Numeric Target Parameters at compliance points; Turbidity by water agencies.

4 Direct measurement of sediment loading is not proposed for this TMDL. Parameters characterizing the effect of loading are to be measured instead, and are identified as Numeric Targets. This 25-year schedule for achieving the TMDL acknowledges that implementation actions taken in the near term are expected to take years to produce a response as measured through Numeric Target monitoring.

At End of Implementation Year:	IMPLEMENTATION MILESTONE	MONITORING ACTIVITY[4]
12	Implementing Parties submit report on progress of actions; RB staff and SLR TAC meet to review progress on implementation actions and monitoring; RB staff consider modifications to Trackable Implementation Actions; RB requests implementation tracking report from Implementing Parties if not provided; RB staff calculate 10-year rolling average of streambed sediment data and turbidity;	Turbidity by water agencies.
13	RB staff and SLR TAC meet to review progress on implementation actions; RB staff calculate 10-year rolling average of streambed sediment data and turbidity;	Turbidity by water agencies.
14	RB staff and SLR TAC meet to review progress on implementation actions; RB staff calculate 10-year rolling average of streambed sediment data and turbidity;	Full suite of Numeric Target Parameters at compliance points; Turbidity by water agencies.
15	Implementing Parties submit report on progress of actions; RB staff and SLR TAC meet to review progress on implementation actions and monitoring; RB staff consider modifications to Trackable Implementation Actions; RB requests implementation tracking report from Implementing Parties if not provided; RB staff calculate 10-year rolling average of streambed sediment data and turbidity;	Turbidity by water agencies.
16-24	*Repeat as above with 1- and 3-year milestones*	
25	Numeric Targets Achieved; Load reduction Achieved	

IX. E. TOTAL MAXIMUM DAILY LOADS FOR PATHOGENS FOR MORRO BAY AND CHORRO AND LOS OSOS CREEKS

The Regional Water Quality Control Board adopted this TMDL on May 16, 2003.
This TMDL was approved by:
The State Water Resources Control Board on September 16, 2003.
The California Office of Administrative Law on November 11, 2003.
The U.S. Environmental Protection Agency on January 20, 2004.

TMDL Elements

<table>
<tr><th>Element</th><th></th></tr>
<tr><td>Problem Statement</td><td>Numeric water quality objectives for fecal coliform set by the Regional Board and standards enforced by the California Department of Health Services (DHS) pursuant to the United States Department of Health Services Food and Drug Administration's National Shellfish Sanitation Program have been exceeded for shellfish harvesting and water contact recreation in Morro Bay. Elevated levels of fecal coliform in Morro Bay and Chorro and Los Osos Creeks indicate that pathogens are impairing water contact recreation and shellfish harvesting in these water bodies. High levels of pathogens may cause disease in humans and may also adversely affect marine animals. Portions of Morro Bay have been closed by DHS for commercial shellfish harvesting since 1996, and advisories have been posted to warn the public to avoid water contact activities. Morro Bay was identified as impaired for pathogens on the 1998 Clean Water Act Section 303(d) list of impaired water bodies.</td></tr>
<tr><td>Numeric Targets</td><td>Numeric targets for Morro Bay, based on regulations[1] that DHS follows
<table>
<tr><th colspan="2">Fecal Coliform</th></tr>
<tr><th>Geometric Mean</th><th>Maximum</th></tr>
<tr><td>14 MPN/100 mL[a]</td><td>43 MPN/100 mL[b]</td></tr>
</table>
a: Based on the geometric mean of monthly sampling
b: No more than 10% of total samples may exceed this number

Numeric targets for Chorro and Los Osos Creeks and fresh water seeps[2] to Morro Bay, based on Basin Plan objective
<table>
<tr><th colspan="2">Fecal Coliform</th></tr>
<tr><th>Geometric Mean</th><th>Maximum</th></tr>
<tr><td>200 MPN/100 mL[a]</td><td>400 MPN/100 mL[b]</td></tr>
</table>
a: Geometric mean of not less than five samples over a period of 30 days
b: Not more than 10% of total samples during a period of 30 days exceed</td></tr>
</table>

1 National Shellfish Sanitation Program, Model Ordinance. Chapter IV, 0.02, D
2 Seeps are defined as any surfacing ground water flowing into Morro Bay from the east shore of the Bay, south of Los Osos Creek.

Allocations and TMDL	This TMDL is expressed as concentrations that are equal to the numeric targets. For Bay waters, a geometric mean of 14 MPN/100 mL must be achieved and no more than 10% of the samples may be over 43 MPN/100 mL for fecal coliform. For tributaries (Chorro and Los Osos Creeks and fresh water seeps) to the Bay, the geometric mean shall not exceed 200 MPN/100 mL over a 30-day period nor shall 10% of the samples exceed 400 MPN/100 mL over any 30-day period for fecal coliform. Point and nonpoint sources cannot exceed the concentrations specified above. Therefore, the wasteload allocations and load allocations, which include background levels, are also equal to the numeric targets.
Margin of Safety	A margin of safety has been established implicitly through the use of protective numeric targets.
Linkage Analysis	Allocations are equal to the numeric targets which equal the water quality objectives.
Implementa-tion	The bacterial load to Morro Bay derives from nonpoint sources (NPS) and point sources. As such, implementation will rely on the State's Plan for NPS pollution control (CWC §13369) and continued implementation of existing regulatory controls as appropriate for point sources, including storm water pursuant to NPDES surface water discharge regulations and Waste Discharge Requirements (Porter Cologne). Implementation emphasizes the activities of the Morro Bay National Estuary Program, Coastal San Luis Resources Conservation District, Farm Bureau, University of California Cooperative Extension, Natural Resources Conservation Service, Public/Private Landowners, Morro Bay Harbor Department, California Department of Fish and Game, City of Morro Bay, United States Coast Guard, San Luis Obispo County, Division of Animal Services, all of whom are not currently identified as dischargers responsible for bacterial loading, to implement self-determined activities (see Table: Trackable Implementation Actions (self-determined)). Other actions, currently required because of another Regional Water Quality Control Board (Regional Board) regulatory program, will be evaluated to make sure progress is taking place (see Table: Trackable Implementation Actions identified under existing regulatory programs). Regional Board Staff will meet annually with the implementing parties identified in the list of Trackable Implementation Actions Tables to provide technical assistance and to evaluate and track progress (see Table: Morro Bay TMDL for Pathogens Implementation Schedule for details). If at the end of year three, implementing parties fail to complete these self-determined activities and/or resulting management practices fail to reduce bacterial loads and/or the numeric targets are not being met, then Regional Board staff will conduct inspections and investigations to identify individual responsible dischargers (e.g., landowners or public agencies). Regional Board staff may rely on Section 13267 of the California Water Code for investigation and identification of individual responsible dischargers. Regional Board staff will also rely on Section 13267 of the California Water Code to require reporting and/or monitoring to determine the level of implementation of identified activities to reduce bacteria. If necessary, the Regional Board may rely on enforcement authority, pursuant to California Water Code Section 13304, to require dischargers to clean-up and abate bacterial discharges and/or prevent the threat of discharges on a case-by case basis. Additionally, Implementation Actions (in the Table of Implementation Actions) may be identified as conditions of compliance with storm water permits and Waste Discharge Requirements. If at the end of the third year, self-determined actions have not been initiated, staff will develop a regulatory approach (rather than a self-determined approach) and present a revised implementation plan to the Regional Board as a Basin Plan Amendment.
Monitoring	Monitoring will be performed and evaluated by the DHS according to their regulations, the Morro Bay National Estuary Volunteer Program and the Regional Board to ensure

	that numeric targets are met and implementation actions are taking place. Should the Morro Bay National Estuary Volunteer Program be unable to sample, the Regional Board will sample to the extent practicable. Regional Board staff will review data on a triennial basis, at a minimum, and determine if progress towards fecal coliform reduction is adequate and whether changes to implementation actions are warranted (as described above).

Trackable Implementation Actions (self-determined)

PROJECT NAME	ACTION	SCHEDULE	IMPLEMENTING PARTIES
Grazing Management	Implement grazing management measures that reduce bacterial levels	Ongoing - 2012	MBNEP, CSLRCD, Farm Bureau, UCCE, NRCS, Public/Private Landowners
Boat Management, Pump-outs	Upgrade pump-out facilities, provide new facilities, improve accessibility	2002-2005	MBHD
Remove unpermitted moorings	Remove illegal moorings and prevent future ones	Ongoing - 2007	CDFG, MBNEP
Remove derelict boats	Remove abandoned, derelict boats and vessels in back bay	Ongoing - 2007	CDFG, MBNEP
Manage live aboard boating situation	Continue issuing permits to live aboards, continue with inspections	Ongoing - 2012	City of Morro Bay, USCG, CDFG, MBHD
Educate Public about proper boat waste disposal	Educate public about proper waste disposal	Ongoing - 2012	MBNEP, MBHD
Pet waste management	Create an off leash dog park, provide supplies to pick-up pet waste, ordinance	Ongoing - 2012	MBNEP, City of Morro Bay, San Luis Obispo County
Septic System Maintenance	Inspect and maintain all septic systems throughout the watershed	2004 - continuous	San Luis Obispo County, LOCSD
Spay/neuter pets	Educate public to promote spaying and neutering pets	Ongoing - 2012	Division of animal services
Reduce the number of feral dogs/cats	Reduce the number of feral dogs/cats	Ongoing - 2012	Division of animal services, feral cat caretakers

CDFG – California Department of Fish and Game
CSLRCD – Coastal San Luis Resources Conservation District
MBHD – Morro Bay Harbor Department
MBNEP – Morro Bay National Estuary Program
NRCS – Natural Resources Conservation Service
UCCE – University of California Cooperative Extension
USCG – United States Coast Guard
LOCSD – Los Osos Community Services District

Trackable Implementation Actions (under existing regulatory programs)

PROJECT NAME	ACTION	SCHEDULE	RESPONSIBLE DISCHARGERS
Phase II stormwater permit	Incorporate actions to reduce bacteria loading into Morro Bay by implementing a stormwater management plan for the City of Morro Bay and the Community of Los Osos	March 2003 - 2008	City of Morro Bay LOCSD, San Luis Obispo County
Los Osos Community Waste Water Treatment Plant	Construct and maintain a wastewater treatment plant pursuant to Waste Discharge Requirements, R3-2003-0007, Waste Discharge Identification no. 3 401078001	Ongoing - 2007	LOCSD

Implementation Schedule for Morro Bay TMDL for Pathogens

At End of Implementation Year:	IMPLEMENTATION MILESTONE	MONITORING ACTIVITY	Chorro Creek TMDL	Los Osos Creek TMDL	Morro Bay TMDL
1	• RWQCB evaluates data collected over past year, evaluates progress on actions • Meet with VMP, MBNEP, LOCSD, City of MB, County of SLO, DHS, MBHD, State Parks, CDFG, Farm Bureau to discuss progress • LOCSD waste water treatment plant WDR issued • Submittal of stormwater management plan and permit coverage (City of MB, LOCSD)	Fecal coliform			
2	• RWQCB evaluates data collected; evaluates progress on actions				
3	• RWQCB evaluates data collected; evaluates progress on actions • Regional Board evaluates the monitoring of septic system maintenance in the watershed with the County of San Luis Obispo • RWQCB, MBNEP, VMP, LOCSD, City of MB, County of SLO, DHS, MBHD, State Parks, CDFG, Farm Bureau meet to determine TMDL progress.				
4	• RWQCB evaluates data collected; evaluates progress on actions				
5	• RWQCB evaluates data collected; evaluates progress on actions				
6	• RWQCB evaluates data collected; evaluates progress on actions • LOCSD sewer installed • RWQCB, MBNEP, VMP, LOCSD, City of MB, County of SLO, DHS, MBHD, State Parks, CDFG, Farm Bureau meet to determine TMDL progress				
7	• RWQCB evaluates data collected; evaluates progress on actions				
8	• RWQCB evaluates data collected and evaluates progress on actions				
9	• RWQCB evaluates data collected and evaluates progress on actions • RWQCB, MBNEP, VMP, LOCSD, City of MB, County of SLO, DHS, MBHD, State Parks, CDFG, Farm Bureau meet to determine TMDL progress		REC-1 standards achieved	REC-1 standards achieved	DHS Stan-dards, SHELL achieve d
10	• RWQCB evaluates data collected and evaluates progress on actions				
	Load Reduction Achieved; Numeric Targets Achieved				

CDFG – California Department of Fish and Game
DHS – Department of Health Services
LOCSD – Los Osos Community Services District
MB – Morro Bay
MBHD – Morro Bay Harbor Department
MBNEP – Morro Bay National Estuary Program
RWQCB – Regional Water Quality Control Board
SLO – San Luis Obispo
VMP – Volunteer Monitoring Program
WDR – Waste Discharge Requirements

IX. G. TOTAL MAXIMUM DAILY LOAD FOR PATHOGENS FOR SAN LUIS OBISPO CREEK

The Regional Water Quality Control Board adopted this TMDL on December 3, 2004.
This TMDL was approved by:

The State Water Resources Control Board on May 19, 2005.
The California Office of Administrative Law on July 25, 2005. (*Effective date*)
The U.S. Environmental Protection Agency on September 23, 2005.

Problem Statement
The beneficial uses of non-contact water recreation and water contact recreation are not being supported because fecal coliform concentration in San Luis Obispo Creek exceeds existing Basin Plan numeric objectives protecting these beneficial uses.

Numeric Target
Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100mL, nor shall more than ten percent of total samples collected during any 30-day period exceed 400 MPN per 100mL.

Source Analysis
The fecal coliform sources contributing to the problems identified in the Problem Statement are, in decreasing order of contribution: urban, human, birds and bats roosting in the tunnel, livestock, and background. DNA analysis of samples drawn between sites 10.3 and 10.9 (see map in Figure-1) in San Luis Obispo Creek indicate that the following sources and corresponding frequencies are present: human (41%), avian (17%), combined sewer overflow (15%), canine (11%), rodent (5%), dog (4%), raccoon (3%), feline (3%), opossum (1%).

TMDL and Allocations
The TMDL is a receiving water concentration equal to the numeric target. The TMDL is considered achieved when the allocations assigned to individual reaches are consistently met or numeric targets are consistently met in all reaches.

Allocations are expressed as receiving water fecal coliform concentration. Table-1 shows the allocations with respect to location and responsible party. The reaches referred to in Table-1 are illustrated in Figure-1.

Locations of the sites illustrated in Figure-1 are described as follows:

- Site 10.0: located along the main stem of San Luis Obispo Creek (Creek) at the bridge crossing the Creek on Marsh Street. This location is downstream of the confluence of the main stem of the Creek with Stenner Creek.
- Site 10.3: located along the main stem of the Creek at Mission Plaza, immediately downstream of the downstream end of the tunnel.
- Site 10.9: located along the main stem of the Creek at the upstream end of the tunnel.
- STEN0.0: located at the mouth of Stenner Creek before its confluence with San Luis Obispo Creek.
- STEN1.5: located in Stenner Creek at its crossing with Highland Drive on the campus of Cal Poly.
- BRIZ1.0: located in Brizziolari Creek at its crossing with Via Carte Drive on Cal Poly campus; this site is located downstream of the bull-test animal unit.
- Site 12.5: located along the main stem of the Creek at Cuesta Park near the Highway 101 bridge.

Waste Load Allocations: Allocations to the City of San Luis Obispo are waste load allocations (WLAs). The WLAs will be implemented by the City's NPDES permit for the Water Reclamation Facility for control of sewer sources. The WLAs will also be implemented by the City's General Municipal Stormwater permit for the control of urban sources as well as animal sources from the tunnelized area of the Creek.

Allocations to the County of San Luis Obispo are WLAs. The WLAs will be implemented by the County's General Municipal Stormwater permit for the control of urban sources.

A portion of the total allocation to California Polytechnic State University, San Luis Obispo (Cal Poly) is a WLA. The allocation at site STEN1.5 shown in Table-1 is a WLA. The WLA will be implemented by Cal Poly's General Municipal Stormwater permit for the control of urban sources.

Load Allocations: Cal Poly is allocated a load allocation (LA) for the livestock sources along Brizziolari Creek. The LA will be implemented by Cal Poly's WDR permit for the control of animal sources (see site BRIZ1.0 in Table-1).

Allocation for Background: The allocation to Background is included in the WLAs and LA. The background allocation is a receiving water concentration of 81 MPN/100 mL. Therefore, the allocations in Table-1 include the allocation to background.

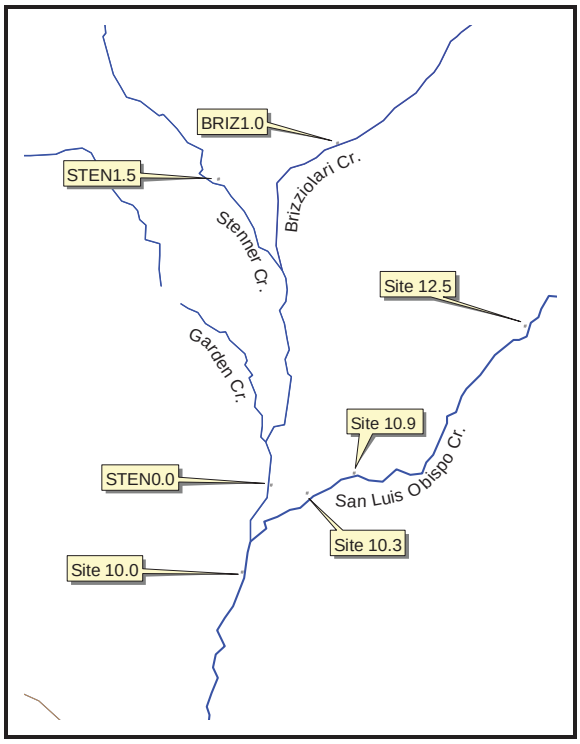

Figure-1: Allocation Sites

Table-1 ALLOCATIONS AND RESPONSIBLE PARTIES				
Allocations in San Luis Obispo Creek				Receiving Water Fecal Coliform Concentration (MPN/100mL)[1]
From Site:	To Upstream Site:	Responsible Party [2, 3, 4]	Allocation Type[5]	
12.5	All upstream sites	County	WLA	≤200
10.9	12.0	City	WLA	≤200
10.0	10.9	City	WLA	≤200
Allocations in Stenner and Brizziolari Creeks				Receiving Water Fecal Coliform Concentration (MPN/100mL)[1]
From Site:	To Upstream Site:	Responsible Party [2, 3, 4]	Allocation Type[5]	
STEN1.5	All upstream sites	Cal Poly	WLA	≤200
STEN0.0	STEN1.5	City	WLA	≤200
BRIZ1.0	All upstream sites	Cal Poly	LA	≤200
Allocations for reaches not specifically noted above: For stream reaches not specifically noted above, the allocation for any discharge loading fecal coliform into San Luis Obispo Creek or any of its tributaries is as follows: Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100mL, nor shall more than 10% of the total samples during any 30-day period exceed 400 MPN per 100mL.				
[1] As log mean of 5 samples taken in a 30-day period occurring within each season. [2] County implies County of San Luis Obispo [3] City implies City of San Luis Obispo [4] Cal Poly implies California Polytechnic State University, San Luis Obispo Campus [5] WLA implies Waste Load Allocation, LA implies Load Allocation				

Margin of Safety

A margin of safety is incorporated in the TMDL through conservative assumptions. The conservative assumptions include: 1) assumption of zero bacterial die-off, 2) TMDL and allocation calculations are predominantly based on data collected during low-flow conditions, which, in the case of San Luis Obispo Creek, skews towards a worst-case scenario.

IMPLEMENTATION

The following actions will occur within one year of TMDL approval by the Office of Administrative Law.

HUMAN SOURCES

The City will implement actions described in Table 3, item 1F, to control human sources as currently required by the NPDES permit for the Water Reclamation Facility (WRF).

The Executive Officer (EO) or the Regional Board will amend the Monitoring and Reporting Program (M&RP) of the City's NPDES permit for the WRF to incorporate stream monitoring for fecal coliform. The EO or Regional Board will also amend the M&RP to incorporate reporting of such stream monitoring activities.

URBAN SOURCES

The City will amend its Storm Water Management Plan (SWMP) to include actions described in Table-3, items 1A, 1B, 1C, 1D, and 1E, pursuant to Section D of State Board Order No. 2003-005, NPDES General Permit No. CAS000004 for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems (Small MS4 Permit). The City will then describe the actions taken in Table-3 as part of its annual report required by the Small MS4 Permit. If the City does not make these changes by submittal of the next annual report, the Executive Officer will require such changes.

The Executive Officer or the Regional Board will amend the Monitoring and Reporting Program of the City's small MS4 Permit to incorporate stream monitoring of fecal coliform and reporting of such monitoring, if additional monitoring-beyond that amended to the Monitoring and Reporting Program for the City's NPDES Permit for the WRF-is necessary.

Cal Poly will amend their SWMP to include specific actions described in Table-3, items 3A, 3B, and 3D. Cal Poly will then describe actions taken in Table-3 as part of their annual report required by the Small MS4 Permit. If Cal Poly does not make these changes by submittal of next annual report for this permit, the Executive Officer will require such changes.

The County of San Luis Obispo (County) will amend its SWMP to include specific actions described in Table-3, items 2A, 2B, 2C, and 2D, pursuant to Section D of the Small MS4 Permit. The County will then describe actions taken in Table-3 as part of its annual report required by the Small MS4 Permit. If the County does not make these changes by submittal of next annual report for this permit, the Executive Officer will require such changes.

LIVESTOCK SOURCES

Cal Poly will eliminate discharges of animal waste from seepage to surface waters from irrigated wastewater and flow to surface waters from confined animal operations, as currently required by Cal Poly's Waste Discharge Requirements.

Cal Poly has agreed to use management practices described in Table-3, item 3C, as described in its Water Quality Management Plan.

Cal Poly will conduct stream monitoring and report results as currently required by the M&RP of Cal Poly's Waste Discharge Requirements.

Additionally, the EO will amend the M&RP associated with Cal Poly's Waste Discharge Requirements to require annual reporting of specific measures that have been identified in the Water Quality Management Plan and have been and/or will be taken to reduce fecal coliform loading from livestock and urban sources.

THREE-YEAR REVIEWS

Regional Board staff will conduct a review every three years beginning three years after TMDL approval by the Office of Administrative Law. Regional Board staff will utilize Annual Reports, as well as other available information, to review water quality data and implementation efforts of responsible parties and progress being made towards achieving the allocations and the numeric target. Regional Board staff may conclude and articulate that ongoing implementation efforts may be insufficient to ultimately achieve the allocations and numeric target. If staff makes this determination, staff will recommend that additional reporting, monitoring, or implementation efforts be required either through approval by the Executive Officer (e.g. pursuant to CWC section 13267 or section 13383) or by the Regional Board (e.g. through revisions of existing permits and/or a Basin Plan Amendment). Regional Board staff may conclude and articulate that to date, implementation efforts and results are likely to result in achieving the allocations and numeric target, in which case existing and anticipated implementation efforts should continue.

Three-year reviews will continue until the TMDL is achieved. The target date to achieve the TMDL is ten years after implementation commences.

Table-3 IMPLEMENTATION ACTIONS OF RESPONSIBLE PARTIES			
Responsible Party	Item	**Best Management Practice**	**Discussion**
City of San Luis Obispo	1A	Public Participation and Outreach	Educate the public regarding sources of fecal coliform and associated health risks of fecal coliform in surface waters. Educate the public regarding actions that individuals can take to reduce loading.
	1B	Pet Waste Management	Develop and implement enforceable means (e.g. an ordinance) of reducing/eliminating fecal coliform loading from pet waste.
	1C	Wild Animal Waste Management	Develop and implement strategies to reduce/eliminate fecal coliform loading from wild animals inhabiting the tunnelized area of the Creek.
	1D	Illicit Discharge Detection and Elimination	Develop and implement strategies to detect and eliminate illicit discharges (whether mistaken or deliberate) of sewage to the Creek.
	1E	Pollution Prevention and Good Housekeeping	Develop and implement strategies to reduce/eliminate fecal coliform loading from streets, parking lots, sidewalks, and other urban areas potentially collecting and discharging fecal coliform to the Creek.
	1F	Human Source Elimination and Prevention	Maintain the sewage collection system, including identification of sewage leaks, the correction of sewage leaks, and prevention of sewage leaks.
County of San Luis Obispo	2A	Public Participation and Outreach	Educate the public regarding sources of fecal coliform and associated health risks of fecal coliform in surface waters. Educate the public regarding actions that individuals can take to reduce loading.
	2B	Pet Waste Management	Develop and implement enforceable means (e.g. an ordinance) of reducing/eliminating fecal coliform loading from pet waste.
	2C	Illicit Discharge Detection and Elimination	Develop and implement strategies to detect and eliminate illicit discharges (whether mistaken or deliberate) of sewage to the Creek.
	2D	Pollution Prevention and Good Housekeeping	Develop and implement strategies to reduce/eliminate fecal coliform loading from streets, parking lots, sidewalks, and other urban areas potentially collecting and discharging fecal coliform to the Creek.
Cal Poly State University	3A	Public Participation and Outreach	Educate the public regarding sources of fecal coliform and associated health risks of fecal coliform in surface waters. Educate the public regarding actions that individuals can take to reduce loading.
	3B	Pet Waste Management	Develop and implement enforceable means of reducing/eliminating fecal coliform loading from pet waste.
	3C	Grazing Management	Develop and implement strategies to reduce/eliminate fecal coliform loading from livestock grazing.
	3D	Pollution Prevention and Good Housekeeping	Develop and implement strategies to reduce/eliminate fecal coliform loading from streets, parking lots, sidewalks, and other urban areas potentially collecting and discharging fecal coliform to the Creek.

IX. G. SAN LUIS OBISPO CREEK TOTAL MAXIMUM DAILY LOAD AND IMPLEMENTATION PLAN FOR NITRATE-NITROGEN

The Regional Water Quality Control Board adopted this TMDL on September 9, 2005.
This TMDL was approved by:
The State Water Resources Control Board on June 21, 2006.
The California Office of Administrative Law on August 4, 2006. (*Effective date*)
The U.S. Environmental Protection Agency on January 10, 2007.

Problem Statement
The municipal and domestic supply of water beneficial use (MUN) is not being supported because nitrate-N concentrations in San Luis Obispo Creek exceed the existing Basin Plan numeric objective protecting the MUN beneficial use.

Numeric Target
The numeric target used to calculate the TMDL is a nitrate-N concentration of 10 mg/L-N.

Source Analysis
Nitrate-N sources contributing to the problem identified in the Problem Statement are, in decreasing order of contribution: City of San Luis Obispo Water Reclamation Facility (WRF), croplands, background, reservoirs, and residential areas.

TMDL and Allocations
The TMDL is a receiving water nitrate-N concentration equal to the numeric target. The following allocations are necessary to achieve the TMDL.

Wasteload Allocations:

- City of San Luis Obispo WRF effluent: The monthly mean nitrate-N concentration of effluent shall not exceed 10 mg/L-N.

Load Allocations:
- Croplands in Prefumo Creek Watershed: shall not cause nitrate-N concentration in receiving waters to exceed 10 mg/L-N.
- Background: Nitrate concentration of 0.1 mg/L-N.

Load and wasteload allocations to sources currently meeting water quality standards:
- The following wasteload and load allocations ensure that the receiving water will achieve compliance with water quality standards at the earliest possible date, continue to meet water quality standards after the above wasteload and load allocations are attained, and comply with state and federal anti-degradation requirements.
    - Residential Sources Wasteload Allocation:
        - Storm water discharge shall not cause an increase in receiving water nitrate-N concentration greater than the current increase in nitrate-N concentration resulting from the discharge.

    - Reservoir Sources Load Allocation (Laguna Lake):
        - Reservoir discharge shall not cause an increase in receiving water nitrate-N concentration greater than the current increase in nitrate-N concentration resulting from the discharge.

Margin of Safety: Nitrate concentration of 2.2 mg/L-N.

IMPLEMENTATION

The following actions will be taken to implement the TMDL.

WRF Source:

- The Central Coast Water Board will incorporate an effluent limit for nitrate-N in the City of San Luis Obispo's National Pollutant Discharge Elimination System permit (NPDES permit) for the WRF, consistent with the allocations described in the Wasteload Allocations section above. The effluent limit will be incorporated in the NPDES permit at the first permit renewal following TMDL approval by the Central Coast Water Board (expected in May 2007).
- The Central Coast Water Board intends to issue a Cease and Desist Order (CDO) or Time Schedule Order to the WRF concurrently with the NPDES permit, requiring the WRF to reduce nitrate-N concentration in the effluent. The CDO will contain a time schedule establishing the time allowed to comply with the order.
- The Central Coast Water Board will consider a revision of the wasteload allocation and corresponding effluent limit for the WRF if an amendment to the Basin Plan removing or revising the MUN beneficial use and corresponding numeric objective for nitrate is approved by USEPA.

Residential Source (Storm water):

- The City of San Luis Obispo, the County of San Luis Obispo, and Cal Poly State University will implement management practices consistent with and required by Small MS4 Permits regulating storm water discharge in San Luis Obispo Creek watershed, and will submit annual reports as required by such permits. If implementation actions are insufficient to achieve the TMDL, additional implementation actions will be required through approval by the Executive Officer (e.g., pursuant to CWC section 13267 or section 13383) or by the Central Coast Water Board (e.g., by requiring revisions of existing storm water management plans and/or a Basin Plan Amendment).

Reservoir Source

- Implementation measures to achieve the allocation to the reservoir source are carried out through the Residential Source (Storm water) implementation actions.

Cropland Source:

- Landowners and operators of irrigated lands in Prefumo Creek watershed will implement actions needed to achieve the allocations to croplands pursuant to the Conditional Waiver of Waste Discharge Requirements for Discharges to Irrigated Lands (Conditional Waiver). Implementation and monitoring requirements for parties engaged in agricultural activities are consistent with, and rely upon, the Conditional Waiver.
- Monitoring reports and data associated with the Conditional Waiver, as well as other information, will be used to determine whether management measures being taken are sufficient to achieve the TMDL by the year 2012. Central Coast Water Board staff will make this determination every three years as described in the Tracking and Monitoring section below. If implementation actions are insufficient to achieve the TMDL, additional implementation actions will be required through approval by the Executive Officer (e.g., pursuant to CWC section 13267 or section 13383) or by the Central Coast Water Board; the Executive Officer or the Central Coast Water Board will approve of additional actions as soon as practicable.

Monitoring

The following actions will be taken to implement monitoring requirements.

- The Executive Officer (EO) or the Central Coast Water Board will amend the Monitoring and Reporting Program (M&RP) of the City's NPDES permit for the WRF to incorporate effluent and stream monitoring for nitrate-N, and to incorporate reporting of these monitoring activities. The City of San Luis Obispo will comply with the amended M&RP as soon as the EO or the Water Board issues the revised program (anticipated to occur at the next permit renewal following TMDL approval by the Central Coast Water Board [expected in May 2007]).
- Implementation and monitoring requirements for parties engaged in agricultural activities are consistent with, and rely upon, the Conditional Waiver.

Tracking and Monitoring

- Central Coast Water Board staff will conduct a review of implementation activities every three years, beginning three years after TMDL approval by the Office of Administrative Law, unless funding is unavailable. Central Coast Water Board staff will utilize annual reports associated with Small MS4 permits, as well as other available information, to review water quality data and implementation efforts of implementing parties and progress being made towards achieving the allocations and the numeric target. Central Coast Water Board staff may conclude that ongoing implementation efforts may be insufficient to ultimately achieve the allocations and numeric target. If staff makes this determination, staff will recommend that additional reporting, monitoring, or implementation efforts be required either through approval by the Executive Officer (e.g., pursuant to CWC section 13267 or section 13383) or by the Central Coast Water Board (e.g., through revisions of existing permits and/or a Basin Plan Amendment). Central Coast Water Board staff may conclude that to date, implementation efforts and results are likely to result in achieving the allocations and numeric target, in which case existing and anticipated implementation efforts will continue.

  Three-year reviews will continue until the TMDL is achieved, unless funding is unavailable. The target date to achieve the TMDL is during or before the year 2012.

IX. H. PAJARO RIVER TOTAL MAXIMUM DAILY LOADS FOR SEDIMENT INCLUDING LLAGAS CREEK, RIDER CREEK, AND SAN BENITO RIVER

The Regional Water Quality Control Board adopted this TMDL on December 2, 2005.
This TMDL was approved by:

The State Water Resources Control Board on September 21, 2006.
The California Office of Administrative Law on November 27, 2006. (*Effective date*)
The U.S. Environmental Protection Agency on May 3, 2007.

Problem Statement

Anthropogenic watershed disturbances have accelerated the natural processes of erosion and sedimentation in the Pajaro River, including Llagas Creek, Rider Creek, and San Benito River. Special studies have identified a variety of watershed conditions that have lead to excessive sedimentation. Excessive sedimentation has caused an exceedance of the narrative, general water quality objective for sediment because sediment load and rate have interfered with the beneficial uses of these waterbodies including, fish and wildlife (COLD, MIGR, and SPWN).

The narrative objective states, “the suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.”

Numeric Targets (interpretation of the narrative water quality objective)

This TMDL establishes numeric targets as indicators of the narrative, general water quality objective for sediment. This TMDL uses two types of numeric targets: suspended sediment concentration-duration and streambed characteristics. Numeric targets for suspended sediment concentration-duration are presented in Table 1. Numeric targets for streambed characteristics are presented in Table 2.

Table 1 - Numeric Targets for Suspended Sediment Conditions

Major Subwatershed [a]	Exposure Category [b]		Exceedance Event Criteria		Numeric Targets [c]	
	Duration (consecutive days)	Suspended Sediment Concentration Range (mg/L) [d]	Duration (consecutive days)	Suspended Sediment Concentration (mg/L)	Maximum Number of Exceedance Events	Maximum Duration of any given Exceedance Event (consecutive days)
Tres Pinos	1	666 – 1808	2	>1808	15	22
	2	245 – 665	3	>665	42	44
	6	91 – 244	7	>244	36	51
	14	91 – 244	15	>244	20	51
	49	33 – 90	50	>90	5	108
San Benito	1	666 – 1808	2	>1808	9	9
	2	245 – 665	3	>665	30	21
	6	91 – 244	7	>244	29	35
	14	91 – 244	15	>244	14	35
	49	33 – 90	50	>90	2	60
Llagas	1	666 – 1808	2	>1808	0	0
	2	245 – 665	3	>665	0	1
	6	91 – 244	7	>244	9	15
	14	91 – 244	15	>244	1	15
	49	33 – 90	50	>90	0	28
Uvas	1	666 – 1808	2	>1808	1	3
	2	245 – 665	3	>665	12	8
	6	91 – 244	7	>244	12	15
	14	91 – 244	15	>244	1	15
	49	33 – 90	50	>90	0	18
Upper Pajaro	1	666 – 1808	2	>1808	0	1
	2	245 – 665	3	>665	3	3
	6	91 – 244	7	>244	2	9
	14	91 – 244	15	>244	0	9
	49	33 – 90	50	>90	0	33
Corralitos (includes Rider Creek)	1	666 – 1808	2	>1808	0	1
	2	245 – 665	3	>665	0	2
	6	91 – 244	7	>244	8	11
	14	91 – 244	15	>244	0	11
	49	33 – 90	50	>90	0	36
Mouth of Pajaro	1	666 – 1808	2	>1808	0	1
	2	245 – 665	3	>665	0	2
	6	91 – 244	7	>244	8	11
	14	91 – 244	15	>244	0	11
	49	33 – 90	50	>90	0	36

[a] Major subwatersheds of the Pajaro River.

[b] Five exposure categories per major subwatershed. Each exposure category is comprised two components: a duration (consecutive days) and a suspended sediment concentration (SSC) range in milligrams per liter (mg/L).

[c] Numeric targets are comprised of two components: a maximum number of exceedance events that may occur in any consecutive 15 years after development of the monitoring program and the maximum duration (consecutive days) in which the maximum SSC value for each range can be exceeded in 15 years. Exceedance events are specific to each exposure category and consist of consecutive days in which the duration and the maximum SSC value for each range is exceeded. Using the exposure category of 1-day, 666-1,808 mg/l SSC range for Tres Pinos as an example; the maximum number of exceedance events (e.g. 2-days or longer and greater than 1,808 mg/L) is 15. The maximum duration is 22 days. Using the same Tres Pinos example, numeric targets are not met if the number of exceedance events is 16 (or more) or if the maximum duration of any event is 23 consecutive days or longer.

[d] Numbers rounded to show measurable break in the range.

Table 2 - Numeric Targets for Streambed Characteristics

Parameter	**Numeric Target**[1]
Residual Pool Volume[2]	V* = Mean values $\leq$ 0.21 Max values $\leq$ 0.45
Median Diameter (D_{50}) of Sediment Particles in Spawning Gravels	D_{50} = Mean values $\geq$ 69 mm Minimum values $\geq$ 37 mm
Percent of Fine Fines (< 0.85 mm) in Spawning Gravels	Percent fine fines $\leq$ 21%
Percent of Coarse Fines (< 6.0 mm) in Spawning Gravels	Percent coarse fines $\leq$ 30%

1 Target values are for sampling reach(es) within an individual waterbody.

2 Residual Pool Volume refers to the portion of a pool in a stream that is available for fish to occupy. Pool habitat is the primary habitat for steelhead in summer. Overwintering habitat requirements include deeper pools, undercut banks, side channels, and especially large, unembedded rocks, which provide shelter for fish against the high flows of winter. V* gives a direct measurement of the impact of sediment on pool volume. It is the ratio of the amount of *pool volume filled by fine, mobile sediment*, to *total pool volume*. Qualifying pools are defined by Regional Board sampling protocol (2002).

Source Analysis

Sources of sediment include the following nonpoint and point source discharge activities occurring within the respective land use source categories. Nonpoint sources include irrigated agriculture activities upon crop, fallow and orchard lands; timber harvesting activities upon forested lands; grazing activities upon pasture and range lands; urban and rural residential development, roads, farm animal and livestock boarding upon urban lands; unpaved roads in the San Benito watershed, and paved and unpaved roads in the Corralitos Creek and Rider Creek watersheds upon lands in the roads landuse category; hydromodification-related activities upon all types of land use; off-road recreational vehicle areas; sand and gravel mining; as well as natural erosion and landslides. Point sources include the small Municipal Separate Storm Sewer Systems (MS4s) of Watsonville, Hollister, Gilroy, and Morgan Hill.

TMDLs and Allocations

TMDLs and load allocations are assigned to sources for seven watersheds as represented in Table 3. These allocations are modeled load values that are necessary to meet the suspended sediment concentration-duration targets. The Regional Board will determine that the TMDL is attained when the numeric targets are achieved. When numeric targets are achieved, the Regional Board will assume that these loads are met.

Margin of Safety

The total load includes an implicit margin of safety that was derived through conservative assumptions.

Table 3 – TMDLs and Load Allocations

		Source Category							
Major Subwatershed	Allocations[1] (LA/WLA)	Crop, Fallow, and Orchard	Forest [2]	Pasture and Range	Urban Lands [3]	Roads	Barren [2]	Sand and Gravel Mining	Total Load
Tres Pinos	LA	477	352	41085	312		11551		53,778
	WLA				1				
San Benito	LA	1971	2083	19863	327	1180	14128	27	39,679
	WLA				100				
Llagas	LA	596	326	6978	354		144	0	9,185
	WLA				787				
Uvas	LA	946	989	12454	280		369		15,177
	WLA				139				
Upper Pajaro	LA	4114	1228	37664	356		425	3	43,951
	WLA				161				
Corralitos (including Rider Creek)	LA	3544	4536	2427	443	79	73	2	11,389[4]
	WLA				284				
Mouth of Pajaro	LA	3047	58	3055	383		500	35	7,268[4]
	WLA				191				

Notes:
1 Annual load allocations (LA) and waste load allocations (WLA) expressed in metric tons (1 metric ton equals 1,000 kilograms). Blank cells indicate no allocations for specified source category.
2 Forest includes loads from natural sources and from timber harvesting operations; Barren includes loads from natural sources only.
3 Load allocations for urban lands outside of NPDES Phase 2 urban boundaries. Waste load allocations for urban lands within NPDES Phase 2 urban boundaries.
4 Number rounded.

Implementation
The following actions will be taken to reduce sediment discharges from activities that occur within each of the land use source categories (headings) below. Regional Board staff intends to identify and notify the parties responsible for the activities according to the schedule below; however, if staff resources are insufficient or other water quality priorities emerge, this schedule will be modified.

Crop, Fallow, and Orchard Lands
Landowners and operators of crop, fallow, and orchard lands, where irrigated agricultural activities are conducted, will implement agricultural management measures and perform monitoring and reporting pursuant to the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands and the Monitoring and Reporting Program, Order No. R3-2004-0117. This is an existing, on-going activity.

Forest Lands
Landowners and operators of forest lands, where timber harvest activities are conducted, will implement timber harvest management measures and perform monitoring and reporting pursuant to the General Conditional Waiver

of Waste Discharge Requirements for Timber Harvest Activities and the Monitoring and Reporting Program, Order No. R3-2005-0066. This is an existing, on-going activity.

Pasture and Range

Owners and operators of pasture and range lands, where grazing activities occur, must comply with the land disturbance prohibition.

Within one year following approval of the TMDLs by the Office of Administrative Law, the Executive Officer will notify the owners and operators of pasture and range lands of the prohibition and conditions for compliance with the prohibition. The Executive Officer will review and approve, or request modification of, the Nonpoint Source Pollution Control Implementation Program (Program) or documentation submitted in compliance with the prohibition within six months of the submittal date. Should the Program or documentation require modification, or if a party fails to submit a Program or documentation, the Executive Officer may issue a civil liability complaint pursuant to section 13268 or 13350 of the CWC, or alternatively, propose individual or general waste discharge requirements to assure compliance with the prohibition.

Urban Lands

Urban lands include the small communities of Watsonville, Hollister, Gilroy, and Morgan Hill (cities), rural properties throughout the watershed with farm animals or livestock boarding (rural properties), and roads throughout the watershed. These lands do not include unpaved roads in San Benito River watershed, and paved and unpaved roads within the Corralitos Creek and Rider Creek subwatersheds (See Roads below).

The cities must obtain a Municipal Separate Storm Sewer System (MS4) permit. Their Storm Water Management Programs must include specific actions to reduce sediment discharges pursuant to Clean Water Act Section 402(p)(3)(B) and Section D of State Board Order No. 2003-005, NPDES General Permit No. CAS000004 for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems. The cities will then describe the actions taken as part of their annual report. If necessary, the Regional Board's Executive Officer can require more stringent sediment controls. This is an existing requirement and an on-going activity.

Owners and operators of rural properties and roads must comply with the land disturbance prohibition.

Within one year following approval of the TMDLs by the Office of Administrative Law, the Executive Officer will notify the owners and operators of rural properties and roads of the prohibition and conditions for compliance with the prohibition. The Executive Officer will review and approve, or request modification of, the Program or documentation submitted in compliance with the prohibition within six months of the submittal date. Should the Program or documentation require modification, or if a party fails to submit a Program or documentation, the Executive Officer may issue a civil liability complaint pursuant to section 13268 or 13350 of the CWC, or alternatively, propose individual or general waste discharge requirements to assure compliance with the prohibition.

Roads

Within one year following approval of the TMDLs by the Office of Administrative Law, the Executive Officer will notify the owners and operators of unpaved roads within the San Benito River watershed and paved and unpaved roads within the Corralitos Creek and Rider Creek watersheds of the prohibition and conditions for compliance with the prohibition. The Executive Officer will review and approve, or request modification of, the Program or documentation submitted in compliance with the prohibition within six months of the submittal date. Should the Program or documentation require modification, or if a party fails to submit a Program or documentation, the Executive Officer may issue a civil liability complaint pursuant to section 13268 or 13350 of the CWC, or alternatively, propose individual or general waste discharge requirements to assure compliance with the prohibition.

Sand and Gravel Mining

Within six months following approval of the TMDLs by the Office of Administrative Law and pursuant to Section 13263(e) of the CWC, Regional Board staff will review existing waste discharge requirements (WDRs) for sand and gravel mining operations and revise or require activities to: 1) assess cumulative impacts, including fluvial geomorphic impacts, upon the beneficial uses of the San Benito River; 2) mitigate the impacts identified; and 3) monitor the effectiveness of mitigation activities. One year following approval of the TMDLs by the Office of Administrative Law, pursuant to Section 13267 of the CWC, the Executive Officer will require owners and operators of sand and gravel mining operations to submit a plan to assess cumulative impacts, including fluvial

geomorphic impacts, upon the beneficial uses of the San Benito River. The Executive Officer will comply with the requirements of section 13267 when issuing the orders. Regional Board staff will encourage sand and gravel mining operators to conduct the cumulative impacts assessment cooperatively.

Streambank Erosion

Owners and operators of properties where hydromodification activities occur must comply with the land disturbance prohibition.

Within one year following approval of the TMDLs by the Office of Administrative Law, the Executive Officer will notify the owners and operators of properties where hydromodification activities occur of the prohibition and conditions for compliance with the prohibition. The Executive Officer will review and approve, or request modification of, the Program or documentation submitted in compliance with the prohibition within six months of the submittal date. Should the Program or documentation require modification, or if a party fails to submit a Program or documentation, the Executive Officer may issue a civil liability complaint pursuant to section 13268 or 13350 of the CWC, or alternatively, propose individual or general waste discharge requirements to assure compliance with the prohibition.

Monitoring

Regional Board staff will develop a monitoring program to measure in-stream numeric targets within five years following TMDL approval. The program will be consistent with other Central Coast Region sediment TMDLs, regional sediment monitoring programs, and in cooperation with implementing parties. If Regional Board staff concludes that sediment contributions from individual landowners should be monitored in addition to in-stream numeric targets, the Executive Officer will establish such monitoring requirements in compliance with section 13267.

Tracking and Evaluation

Regional Board staff will conduct a review every three years beginning three years after TMDL approval by the Office of Administrative Law. Regional Board staff will utilize required reports, as well as other available information, to review implementation efforts of responsible parties and progress being made towards achieving the allocations. Regional Board staff will also review numeric target monitoring (see above) to determine progress towards TMDL achievement in the waterbody. The numeric targets, not actual loads or reductions in loads, will be measured, as they are a more direct indicator of beneficial use protection. Regional Board staff may conclude and articulate that ongoing implementation efforts may ultimately be insufficient to achieve the allocations and numeric targets. If staff makes this determination, staff will recommend that additional reporting, monitoring, or implementation efforts be required either by the Executive Officer (e.g. pursuant to CWC section 13267 or section 13383) or by the Regional Board (e.g. through revisions of existing permits and/or a Basin Plan Amendment). At any particular date, Regional Board staff may conclude and articulate that implementation efforts and results are likely to result in achieving the allocations and numeric target, in which case existing and anticipated implementation efforts should continue.

Three-year reviews will continue until the TMDLs are achieved. The target date to achieve the TMDLs is forty-five years after implementation commences.

IX. I. TOTAL MAXIMUM DAILY LOAD FOR PATHOGENS FOR WATSONVILLE SLOUGH

The Regional Water Quality Control Board adopted this TMDL on March 24, 2006.
This TMDL was approved by:

The State Water Resources Control Board on September 21, 2006.
The California Office of Administrative Law on November 20, 2006. (*Effective date*)
The U.S. Environmental Protection Agency on July 19, 2007.

Problem Statement

The beneficial uses of water contact recreation (REC-1) and non-contact water recreation (REC-2) are not supported in Watsonville Slough or its tributaries, Struve, Hanson, Harkins and Gallighan Sloughs, because fecal coliform concentrations there exceed existing Basin Plan numeric water quality objectives protecting these beneficial uses.

Numeric Target

Fecal coliform concentration, based on a minimum of five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100mL, nor shall more than ten percent of total samples collected during any 30-day period exceed 400 MPN per 100mL.

Source Analysis

Controllable sources of fecal coliform bacteria in Watsonville Slough and its tributaries include humans, pets, livestock, and land-applied non-sterile manure in irrigated agriculture. Genetic data indicate that the major sources of fecal coliform causing exceedance of the REC-1 standard are natural avian populations. Genetic analysis of Watsonville Slough water samples from both winter and summer periods confirmed birds, cows, and dogs (with birds contributing the most and dogs the least); human fecal coliform bacteria was confirmed in Harkins and Struve Sloughs, but in lower amounts than cow, bird and dog fecal coliform.

TMDL and Allocations

The TMDL for pathogens in Watsonville Slough is a receiving water concentration equal to the numeric target for fecal coliform. The allocation to each responsible party is the receiving water fecal coliform concentration equal to the TMDL. These allocations focus on reducing or eliminating the controllable sources of fecal coliform. The table below shows the allocations with respect to responsible party and waterbody.

The allocation to background (including natural sources from birds) is also the receiving water fecal coliform concentration equal to the TMDL. The parties responsible for the allocation to controllable sources are not responsible for the allocation to natural sources.

ALLOCATIONS AND RESPONSIBLE PARTIES

WASTE LOAD ALLOCATIONS		Receiving Water Fecal Coliform (MPN/100mL)[1]
Waterbody	**Responsible Party**	
Watsonville, Struve, Harkins Sloughs	Santa Cruz County (Urban Stormwater)	≤200
Watsonville, Struve, Harkins, Gallighan, Hanson Sloughs	City of Watsonville (Urban Stormwater)	≤200
Harkins Slough	Santa Cruz Co. Freedom Sanitation District (Sanitary Sewer Collection System)	≤200
Watsonville & Struve Sloughs	City of Watsonville (Sanitary Sewer Collection System)	≤200
Gallighan Slough	Santa Cruz County (Landfill Stormwater)	≤200
LOAD ALLOCATIONS		**Receiving Water Fecal Coliform (MPN/100mL)[1]**
Watsonville & Harkins Sloughs	Operators or owners of irrigated lands who land-apply non-sterile manure	≤200
Watsonville & Harkins Sloughs	Operators or owners of livestock facilities and animals	≤200
[1] As log mean of five (5) samples taken in a 30-day period occurring within each season.		

The TMDL is considered achieved when the allocations assigned to the controllable and natural sources are met, or when the numeric targets are consistently met in all tributaries and Watsonville Slough.

Margin of Safety
A margin of safety is incorporated in the TMDL through conservative assumptions.

Implementation and Monitoring

Landfill Stormwater Monitoring
Within six months following adoption of this TMDL by the Office of Administrative Law, the Executive Officer will require the County of Santa Cruz to include fecal coliform monitoring in the Buena Vista Landfill Waste Discharge Requirements (Order No. 94-29), per Section 13267 of the CWC.

THE FOLLOWING ACTIONS WILL REDUCE FECAL COLIFORM BACTERIA LOADING FROM HUMANS AND PETS:

Urban Stormwater
The City of Watsonville (City) and County of Santa Cruz (County) must revise their Stormwater Management Plans to indicate how and when they will conduct public participation and outreach regarding specific actions that individuals can take to reduce pathogen loading and to indicate how and when they will develop and implement an enforceable means of reducing fecal coliform loading from pet waste (e.g., an ordinance). Within six months following adoption of this TMDL by the Office of Administrative Law, the Executive Officer will (i) issue a letter pursuant to Section 13383 of the California Water Code (CWC), requiring these changes to be described in the annual report required by the Small MS4 Permit (State Board Order No. 2003-005, NPDES General Permit No.CAS000004 for Municipal Separate Storm Sewer Systems) and (ii) require appropriate modifications to the Stormwater Management Plans pursuant to Section G of the General Permit.

The City and County public participation and outreach efforts must include the following tasks:

a. Educating the public about sources of fecal coliform and its associated health risks in surface waters.
b. Identifying and promoting specific actions that responsible parties can implement to reduce pathogen loading from sources such as homeless encampments, agricultural field workers, and homeowners who contribute waste from domestic pets.

The City and County must monitor receiving water and stormwater outfalls that may be contributing fecal coliform to the sloughs. Within six months following adoption of this TMDL by the Office of Administrative Law, the

Executive Officer will issue a letter pursuant to Section 13267 and/or 13383 of the CWC, requiring a technical report that describes a monitoring plan and schedule that includes sampling sites in receiving water and at stormwater outfalls. The City and County may submit the monitoring results in subsequent annual reports already required by the Small MS4 Permit or submit them in a separate technical report.

Sanitary Sewer Collection System

The City and County are required to improve maintenance of their sewage collection systems, including identification, correction, and prevention of sewage leaks, in portions of the collection systems that run through, or adjacent to, tributaries to Watsonville Slough (Action 1B, Table 1). Within six months following adoption of this TMDL by the Office of Administrative Law, the Executive Officer will issue a letter pursuant to Section 13267 of the CWC, requiring a technical report that describes how and when they will conduct improved system maintenance in portions of the system most likely to affect the Sloughs. One year following adoption of this TMDL by the Office of Administrative Law, Water Board staff will evaluate proposed sewer system maintenance for the City and the County of Santa Cruz Freedom Sanitation District as described in the technical report and determine whether appropriate changes to the maintenance have been made or whether any changes to the Waste Discharge Requirements (currently, Order No. R3-2003-0041, and No. R3-2003-0040, respectively) are warranted.

THE FOLLOWING ACTIONS WILL REDUCE FECAL COLIFORM BACTERIA LOADING FROM LIVESTOCK AND LAND-APPLIED NON-STERILE MANURE:

Livestock Sources

Operators or owners of livestock facilities and animals must comply with the proposed Watsonville Slough Watershed Livestock Waste Discharge Prohibition to implement their load allocations. Within one year following approval of the TMDL by the Office of Administrative Law, the Executive Officer will notify the owners and operators of livestock facilities, and the owners of animals, of the proposed Watsonville Slough Watershed Livestock Waste Discharge Prohibition and conditions for compliance with the prohibition. The Executive Officer will review and approve, or request modification of, the Nonpoint Source Pollution Control Implementation Program (Program) or documentation submitted in compliance with the prohibition within six months of the submittal date. Should the Program or documentation require modification, or if a party fails to submit a Program or documentation, the Executive Officer may issue a civil liability complaint pursuant to section 13268 or 13350 of the CWC, or alternatively, propose individual or general waste discharge requirements to assure compliance with the prohibition. Alternatively, dischargers may comply by immediately ceasing all discharges in violation of the Prohibition.

Responsible parties must submit monitoring data or other evidence that demonstrates compliance with the Watsonville Slough Watershed Livestock Waste Discharge Prohibition. The Executive Officer will determine whether the information submitted demonstrates compliance.

Irrigated Land Sources

Operators or owners of irrigated lands where non-sterile manure is applied must comply with the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands to implement their load allocations. Staff expects management measures implemented pursuant to this waiver for irrigated lands will be adequate to reduce or eliminate pathogen discharges where farmers apply non-sterile manure to the land. However, compliance with the conditions in the waiver does not meet all of the requirements of the proposed Watsonville Slough Watershed Livestock Waste Discharge Prohibition. Since the Conditional Waiver does not include any regulation or monitoring of pathogen discharges, operators or owners of irrigated lands where non-sterile manure is applied must also submit reports that demonstrate that they do not discharge pathogens, or explain how pathogen discharges are being addressed.

Within six months following approval of the TMDL by the Office of Administrative Law, the Executive Officer will notify responsible parties of the proposed Watsonville Slough Watershed Livestock Waste Discharge Prohibition and conditions for compliance with the prohibition. The Executive Officer will review and approve, or request modification of, the Nonpoint Source Pollution Control Implementation Program (Program), or other documentation submitted in compliance with the prohibition, within six months of the submittal date. Should the Program or documentation require modification, or if a responsible party fails to submit a Program or documentation, the Executive Officer may issue an administrative civil liability complaint pursuant to section 13268 or 13350 of the CWC, or alternatively, propose individual or general waste discharge requirements or

conditional waivers to assure compliance with the prohibition. Alternatively, dischargers may comply by immediately ceasing all discharges in violation of the Prohibition.

Tracking and Evaluation

Water Board staff will conduct a review every three years beginning three years after TMDL approval by the Office of Administrative Law. Water Board staff will use Annual Reports and any other available information to determine progress toward compliance. Water Board staff may conclude that ongoing implementation efforts are insufficient to ultimately achieve the allocations and numeric target. If staff makes this determination, staff will recommend that additional reporting, monitoring, or implementation efforts be required either through authority of the Executive Officer (e.g. pursuant to CWC section 13267 or section 13383) or the Water Board (e.g. through revisions of existing permits and/or a Basin Plan Amendment). Water Board staff may also conclude that implementation efforts are likely to achieve compliance, and therefore existing implementation efforts should continue.

Responsible parties will continue monitoring according to this plan for at least three years, at which time Water Board staff will determine the need for continuing or otherwise modifying the monitoring requirements. Responsible parties may also demonstrate that controllable sources of pathogens are not contributing to exceedance of water quality objectives in receiving waters. If this is the case, staff may consider re-evaluating the targets and allocations. For example, staff may propose a site-specific objective for Watsonville Sloughs, to be approved by the Water Board. The site-specific objective would be based on evidence that natural, or "background" sources alone were the cause of exceedances of the Basin Plan water quality objective for fecal coliform.

Three-year reviews will continue until the TMDL is achieved. The target date to achieve the TMDL is ten years after implementation commences.

Table 1. Implementation Actions of Responsible Parties

Responsible Party	Source Category	Management Measure	Action
County of Santa Cruz and City of Watsonville	1A Human	Public Participation and Outreach	Educate the public, including the homeless, regarding sources of fecal coliform and associated health risks of fecal coliform in surface waters of the Watsonville Slough Watershed. Educate the public regarding actions that individuals can take to reduce pathogen loading in the Watershed. Revise Stormwater Management Plan and submit to Water Board for approval, monitor, and report.
	1B Human	Human Source Elimination and Prevention	Maintain the sewage collection system, including identification, correction, and prevention of sewage leaks into tributaries to Watsonville Slough. Revise Sewer System Management Plan and submit to Water Board for approval, monitor, and report.
	1C Pets	Pet Waste Management	Develop and implement enforceable means (e.g., an ordinance) of reducing/eliminating fecal coliform loading from pet waste. Educate the public regarding actions that individuals can take to reduce loading in the Watershed. Revise Stormwater Management Plan and submit to Water Board for approval, monitor, and report.
Operators or owners of livestock facilities and animals	2A Livestock	Farm Animal and Livestock Facilities Management	Develop and implement strategies to reduce/eliminate fecal coliform loading from farm animal and livestock facilities (e.g., pens, corrals, barns) into surface waters of the Watsonville Slough Watershed. Submit *Nonpoint Source Control Implementation Program* to the Executive Officer of the Water Board and monitor and report, or, document and report to the Water Board that no discharge is occurring from animal facilities.
	2B Livestock	Grazing Management	Protect sensitive areas (including streambanks, sloughs, wetlands, and riparian zones) by reducing direct loadings of animal wastes from grazing areas into surface waters of the Watsonville Slough Watershed. Submit *Nonpoint Source Control Implementation Program* to the Executive Officer of the Water Board and monitor and report, or, document and report to the Water Board that no discharge is occurring from grazing activities.
Operators or owners of irrigated lands who land-apply non-sterile manure	3 Land-Applied Non-Sterile Manure on Irrigated lands	Irrigated Land Management	Develop, implement and report on measures to reduce/eliminate fecal coliform loading from land-applied non-sterile manure into surface waters of the Watsonville Slough Watershed. Document and report to the Water Board that measures are in place and monitor to demonstrate effectiveness.

IX. J. TOTAL MAXIMUM DAILY LOADS FOR PATHOGENS IN SAN LORENZO ESTUARY, SAN LORENZO RIVER, BRANCIFORTE CREEK, CAMP EVERS CREEK, CARBONERA CREEK, AND LOMPICO CREEK

The Regional Water Quality Control Board adopted these TMDLs on May 8, 2009.
These TMDLs were approved by:

The State Water Resources Control Board on: March 1, 2011.
The California Office of Administrative Law on: June 6, 2011.
The U.S. Environmental Protection Agency on: July 20, 2011.

Problem Statement

The beneficial use of water contact recreation is not protected in the impaired reaches of the San Lorenzo River Estuary (also known as San Lorenzo River Lagoon), San Lorenzo River , Branciforte Creek, Camp Evers Creek, Carbonera Creek, and Lompico Creek because fecal coliform concentrations exceed existing Basin Plan numeric water quality objectives protecting this beneficial use. All reaches in these waterbodies are impaired with the exception of Carbonera Creek, where the impairment extends from the mouth of Carbonera Creek upstream to its intersection with Bethany Road.

Numeric Targets

The numeric targets used to develop the TMDLs and allocations are as follows:

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL**.**

Source Analysis

San Lorenzo River Estuary
The relative order of controllable sources, in descending order, is:
1) City of Santa Cruz sanitary sewer collection system spills and leaks (including private laterals connected to municipal sanitary sewer collection systems), 2) storm drain discharges to municipally owned and operated separate storm sewer systems (MS4s) required to be covered by an NPDES permit, 3) pet waste in areas that do not drain to MS4s, 4) homeless person/encampment discharges in areas that do not drain to MS4s, 5) onsite wastewater disposal system discharges, and 6) farm animal and livestock discharges.

San Lorenzo River, and Lompico Creek
The relative order of controllable sources, in descending order, is:
1) Onsite wastewater disposal system discharges, 2) storm drain discharges to MS4s required to be covered by an NPDES permit, 3) City of Santa Cruz sanitary sewer collection system spills and leaks (including private laterals connected to municipal sanitary sewer collection systems) within the City limits of Santa Cruz [does not include Lompico Creek], 4) pet waste in areas that do not drain to MS4s, 5) homeless person/encampment discharges in areas that do not drain to MS4s, and 6) farm animal and livestock discharges.

Branciforte Creek,
The relative order of controllable sources, in descending order, is:
1) Storm drain discharges to MS4s required to be covered by an NPDES permit, 2) pet waste in areas that do not drain to MS4s, 3) City of Santa Cruz sanitary sewer collection system spills and leaks (including private laterals connected to municipal sanitary sewer collection systems) within the City limits of Santa Cruz, 4) homeless

person/encampment discharges in areas that do not drain to MS4s, 5) onsite wastewater disposal system discharges, and 6) farm animal and livestock discharges.

Carbonera and Camp Evers Creeks:
The relative order of controllable sources, in descending order, is:
1) Storm drain discharges to MS4s required to be covered by an NPDES permit, 2) pet waste in areas that do not drain to MS4s, 3) homeless person/encampment discharges in areas that do not drain to MS4s, 4) onsite wastewater disposal system discharges (only for Carbonera Creek) 5) farm animal and livestock discharges, and 6) City of Santa Cruz sanitary sewer collection system spills and leaks (including private laterals connected to municipal sanitary sewer collection systems; only for Carbonera Creek).

TMDLs and Allocations

The TMDLs are for the impaired reaches of the following water bodies, and are applicable for each day for all seasons:

San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Camp Evers Creek, Carbonera Creek, and Lompico Creek. TMDLs:

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

The allocations to responsible parties are shown in Table IX J-1.

Table IX J-1. Allocations and Responsible Parties

WASTE LOAD ALLOCATIONS		
Waterbody Assigned Allocation[1]	**Responsible Party** **(Source)** **NPDES/Order number**	**Receiving Water Fecal Coliform (MPN/100mL)**
San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, and Carbonera Creek	City of Santa Cruz (Storm drain discharges to MS4s required to be covered by an NPDES permit) NPDES No. CAS000004	Allocation-1[a]
Camp Evers Creek and Carbonera Creek	City of Scotts Valley (Storm drain discharges to MS4s required to be covered by an NPDES permit) NPDES No. CAS000004	Allocation-1[a]
San Lorenzo River, Branciforte Creek, Lompico Creek, and Carbonera Creek	Santa Cruz County (Storm drain discharges to MS4s required to be covered by an NPDES permit) NPDES No. CAS000004	Allocation-1[a]
San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, and Carbonera Creek	City of Santa Cruz (Sanitary sewer collection system spills and leaks) NPDES No. CA 0048194, Order R3-2005-003	Allocation-2[b]
San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Carbonera Creek , and Lompico Creek	Owners of onsite wastewater disposal systems residing in the County of Santa Cruz (Onsite wastewater disposal system discharges)	Allocation-2[b]
LOAD ALLOCATIONS		
Waterbody	**Responsible Party** **(Source)**	**Receiving Water Fecal Coliform (MPN/100mL)**
San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Carbonera Creek , and Lompico Creek	Owners of onsite wastewater disposal systems residing in the County of Santa Cruz (Onsite wastewater disposal system discharges)	Allocation-2[b]
San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Camp Evers Creek, Carbonera Creek , and Lompico Creek	Owners/operators of land used for/containing pets (Pet waste not draining to MS4s)	Allocation-1[a]
San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Carbonera Creek, Camp Evers Creek, and Lompico Creek	Owners/operators of land used for/containing farm animals and livestock (Farm Animals and Livestock discharges)	Allocation-1[a]

San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Lompico Creek, Camp Evers Creek, and Carbonera Creek	Owners and/or operators of land that include homeless persons/encampments (Discharges from homeless persons/encampments not regulated by a permit for storm water discharges)	Allocation-2[b]
San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Lompico Creek, Camp Evers Creek, and Carbonera Creek	No responsible party (Natural sources)	Allocation-1[a]

1 All reaches of the following water bodies are assigned allocations, excepting Carbonera Creek, where the allocations are assigned from the mouth to the intersection with Bethany Road.

a Allocation-1 = Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN/100mL, nor shall more than ten percent of total samples during any 30-day period exceed 400 MPN/100 mL.

b Allocation-2= Allocation of zero; no loading allowed from this source.

The parties responsible for the allocation to controllable sources are not responsible for the allocation to natural sources.

The TMDLs are considered achieved when the allocations assigned to all individual responsible parties are met or when the numeric targets are consistently met in the San Lorenzo River Estuary, San Lorenzo River, Branciforte Creek, Camp Evers Creek, Carbonera Creek, and Lompico Creek.

Margin of Safety

A margin of safety is incorporated implicitly in the TMDLs through conservative assumptions.

Implementation Plan

SANITARY SEWER COLLECTION SYSTEM LEAKS

Entities with jurisdiction over sewer collection systems can demonstrate compliance with these TMDL allocations through Waste Discharge Requirements and/or NPDES permits.

The City of Santa Cruz and City of Scotts Valley must continue to implement their sewer Collection System Management Plans as required by their respective NPDES permits and Waste Discharge Requirements (WDR) (City of Santa Cruz NPDES No. CA 0048194 and WDR Order R3-2005-003; City of Scotts Valley NPDES No. CA 0048828, WDR Order R3 2002-0016).

In addition, the City of Santa Cruz is required to improve maintenance of their sewage collection system, including identification, correction, and prevention of sewage spills and leaks in portions of the collection systems that run through or adjacent to, impaired surface waters within the San Lorenzo River Estuary or San Lorenzo River. To this end, within six months following approval of these TMDLs by the Office of Administrative Law, the Executive Officer will issue a letter pursuant to Section 13267 of the California Water Code requiring: 1) submittal within one year of a technical report that describes how and when the City of Santa Cruz will conduct improved collection system maintenance in portions of the collection system most likely to affect impaired surface water bodies, with the end result being compliance with its TMDL allocation, 2) stream monitoring for fecal coliform or another fecal indicator bacteria and reporting of these monitoring activities, and 3) annual reporting of self-assessment as to whether the City of Santa Cruz is in compliance with the TMDL allocation.

PRIVATE LATERALS TO THE SANITARY SEWER COLLECTION SYSTEMS

The Central Coast Water Board has identified leaks from private laterals located in the City of Santa Cruz as a source of fecal indicator bacteria in municipal separate storm sewer systems (MS4s). Therefore, enrollees for the City of Santa Cruz' General Permit for the Discharges of Storm Water from Small Municipal Separate Storm

Sewer Systems will address fecal indicator bacteria from private lateral leaks in the Wasteload Allocation Attainment Program (as described in the following section).

STORM DRAIN DISCHARGES TO MUNICIPALLY OWNED AND OPERATED SEPARATE STORM SEWER SYSTEMS

The Central Coast Water Board will address fecal indicator bacteria (FIB), e.g., fecal coliform and/or other indicators of pathogens, discharged from the County of Santa Cruz and the Cities of Santa Cruz and Scotts Valley municipal separate storm sewer systems (MS4 entities) by regulating the MS4 entities under the provisions of the State Water Resources Control Board's General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems (General Permit) (NPDES No. CAS000004). As enrollees under the General Permit, the MS4 entities must develop and implement Storm Water Management Plans (SWMPs) that control urban runoff discharges into and from their MS4s. To address the MS4 entities' TMDL wasteload allocations, the Central Coast Water Board will require the MS4 entities to specifically target FIB in urban runoff through incorporation of Wasteload Allocation Attainment Programs in their SWMPs.

The Central Coast Water Board will require the Wasteload Allocation Attainment Program to include descriptions of the actions that will be taken by the MS4 entities to attain the TMDL wasteload allocations, and specifically address:

1. Development of an implementation and assessment strategy;
2. Source identification and prioritization (including leaks to storm sewers from private laterals);
3. Best management practice identification, prioritization, implementation schedule, analysis, and effectiveness assessment;
4. Monitoring program development and implementation;
5. Reporting, including evaluation whether current best management practices are progressing towards achieving the wasteload allocations within thirteen years of the date that the TMDLs are approved by the Office of Administrative Law.
6. Coordination with stakeholders; and
7. Other pertinent factors.

The Wasteload Allocation Attainment Program will be required by the Central Coast Water Board to address each of these TMDLs that occur within the MS4 entities' jurisdictions.

The Central Coast Water Board will require the Wasteload Allocation Attainment Program to be submitted at one of the following milestones, whichever occurs first:

1. Within one year of approval of the TMDLs by the Office of Administrative Law;
2. When required by any other Central Coast Water Board-issued storm water requirements (e.g., when the Phase II Municipal Storm Water Permit is renewed).

For those MS4 entities that are enrolled under the General Permit at the time of Wasteload Allocation Attainment Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMPs when they are submitted. For those MS4 entities that are not enrolled under the General Permit at the time of Wasteload Allocation Attainment Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMPs when the SWMPs are approved by the Central Coast Water Board.

The Executive Officer or the Central Coast Water Board will require information that demonstrates implementation of the actions described above, pursuant to applicable sections of the California Water Code and/or pursuant to authorities provided in the General Permit for storm water discharges.

PET WASTE, FARM ANIMALS AND LIVESTOCK DISCHARGES

Owners and/or operators of lands containing domestic animals (including pets, farm animals, and livestock) in the San Lorenzo River Watershed must comply with the Domestic Animal Waste Discharge Prohibition; compliance with the Domestic Animal Waste Discharge Prohibition implies compliance with the load allocation for these TMDLs.

Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will notify owners and/or operators of lands used for/containing domestic animals of the requirement to comply with the Domestic Animal Waste Discharge Prohibition. In his notification, the Executive Officer will also describe the options owners/operators of lands containing domestic animals have for demonstrating compliance with the Domestic Animal Waste Discharge Prohibition. Pursuant to California Water Code section 13267 and within six months of the notification by the Executive Officer, owners/operators of lands containing domestic animals will be required to submit one of the following for approval by the Executive Officer or the Central Coast Water Board:

1) Clear evidence that the owner/operator of lands containing domestic animals is and will continue to be in compliance with the Domestic Animal Waste Discharge Prohibition; clear evidence could be documentation submitted by the owner/operator to the Executive Officer validating current and continued compliance with the Prohibition.
2) A plan for compliance with the Domestic Animal Waste Discharge Prohibition. Such a plan must include a list of specific management practices that will be implemented to control discharges containing fecal material from domestic animals. The plan must also describe how implementing the identified management practices are likely to progressively achieve the load allocations to domestic animals, with the ultimate goal of achieving the load allocations no later than thirteen years after Office of Administrative Law approval of the TMDL. The plan must include monitoring and reporting to the Central Coast Water Board, demonstrating the progress towards achieving load allocations for discharges from domestic animals, and a self-assessment of this progress. The plan may be developed by an individual discharger or by or for a coalition of dischargers in cooperation with a third-party representative, organization, or government agency acting as the agents of owners/operators of lands containing domestic animals.
3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements).

ONSITE WASTEWATER DISPOSAL SYSTEM DISCHARGES

Owners of onsite wastewater disposal systems in the San Lorenzo River Watershed must comply with the Human Fecal Material Discharge Prohibition.

Owners of onsite wastewater disposal systems must demonstrate to the satisfaction of the Executive Officer or the Central Coast Water Board that they are in compliance with the Human Fecal Material Discharge Prohibition; compliance with the Human Fecal Material Discharge Prohibition implies compliance with the load allocation for these TMDLs.

Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will either 1) determine that the County of Santa Cruz is making adequate progress towards implementing an approved Santa Cruz County Onsite Wastewater Management Plan (or another Implementation Program to address onsite wastewater disposal systems) as it pertains to controlling the waste loads from onsite wastewater disposal systems in the San Lorenzo River Watershed, or 2) notify owners of onsite wastewater disposal systems (owners) in the area described above of the requirement to comply with the Human Fecal Material Discharge Prohibition. In his notification, the Executive Officer will also describe owners' options for demonstrating compliance with the Human Fecal Material Discharge Prohibition. Pursuant to California Water Code 13267 and within six months of the notification by the Executive Officer, owners will be required to submit one of the following for approval by the Executive Officer or the Central Coast Water Board:

1) Clear evidence that the owner is and will continue to be in compliance with the Human Fecal Material Discharge Prohibition; clear evidence could be verification by the County of Santa Cruz, or similar, that the owner's onsite wastewater disposal system is in compliance with the Human Fecal Material Discharge Prohibition.
2) A schedule for compliance with the Human Fecal Material Discharge Prohibition. The compliance schedule must include a monitoring and reporting program and milestone dates demonstrating progress towards compliance with the Human Fecal Material Discharge Prohibition, with the ultimate milestone being compliance with the Human Fecal Material Discharge Prohibition no later than three years from the date of the Executive Officer's notification to the owner requiring compliance.
3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements; WDRs).

4) Clear evidence of current or scheduled compliance with the Human Fecal Material Discharge Prohibition (as described in number 1 and number 2 above, respectively) through the submittal of the required information by the County of Santa Cruz, acting as the voluntary agents of owners of onsite wastewater disposal systems. Note that an owner of an onsite wastewater disposal system cannot demonstrate compliance with the Human Fecal Material Discharge Prohibition through this option if: 1) the County of Santa Cruz is not their voluntary agent, 2) if the owner of the onsite wastewater disposal system does not choose the County of Santa Cruz as their agent, or 3) the Executive Officer or Central Coast Water Board does not approve the evidence submitted by the County of Santa Cruz on behalf of the owners of onsite wastewater disposal systems.

HOMELESS PERSONS/ENCAMPMENT DISCHARGES NOT REGULATED BY A PERMIT FOR STORM WATER DISCHARGES

Owners of land that contain homeless persons and/or homeless encampments in the San Lorenzo River Watershed must comply with the Human Fecal Material Discharge Prohibition.

Owners of land with homeless persons must demonstrate to the satisfaction of the Executive Officer or the Central Coast Water Board that they are in compliance with the Human Fecal Material Discharge Prohibition; compliance with the Human Fecal Material Discharge Prohibition implies compliance with the load allocation for these TMDLs.

Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will notify owners of land containing homeless persons of the requirement to comply with the Human Fecal Material Discharge Prohibition. In his notification, the Executive Officer will also describe owners' options for demonstrating compliance with the Human Fecal Material Discharge Prohibition. Pursuant to California Water Code 13267 and within six months of the notification by the Executive Officer, owners will be required to submit one of the following for approval by the Executive Officer or the Central Coast Water Board:

1) Clear evidence that the owner is and will continue to be in compliance with the Human Fecal Material Discharge Prohibition; clear evidence could be documentation submitted by the owner to the Executive Officer validating current and continued compliance with the Prohibition.
2) A plan for compliance with the Human Fecal Material Discharge Prohibition. Such a plan must include a list of specific management practices that will be implemented to control discharges containing fecal material from homeless persons. The Plan must also describe how implementing the identified management practices are likely to progressively achieve the load allocation for homeless persons, with the ultimate goal of achieving the load allocation no later than three years from the date of the Executive Officer's notification to the owner requiring compliance. The plan must include monitoring and reporting to the Central Coast Water Board, demonstrating the progress towards achieving load allocations for discharges from homeless persons, and self-assessment of this progress.
3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements).

Tracking and Evaluation

Every three years, beginning three years after TMDLs are approved by the Office of Administrative Law, the Central Coast Water Board will perform a review of implementation actions, monitoring results, and evaluations submitted by responsible parties of their progress towards achieving their allocations. The Central Coast Water Board will use annual reports, nonpoint source pollution control implementation programs, evaluations submitted by responsible parties, and other available information to determine progress toward implementing required actions and achieving the allocations and the numeric target.

Responsible parties will continue monitoring and reporting according to this plan for at least three years, at which time the Central Coast Water Board will determine the need for continuing or otherwise modifying the monitoring requirements. Responsible parties may also demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pathogens are not contributing to the exceedance. If this is the case, the Central Coast Water Board may re-evaluate the numeric target and allocations. For example, the Central Coast Water Board may pursue and approve a site-specific objective based on evidence that natural or background sources alone were the cause of exceedances of the Basin Plan water quality objective for fecal indicator bacteria.

Three-year reviews will continue until the water quality objectives are achieved. The compliance schedule for achieving the TMDL numeric target is 13 years after the date of approval by the Office of Administrative Law.

IX. K. TOTAL MAXIMUM DAILY LOADS FOR PATHOGENS IN SOQUEL LAGOON, SOQUEL CREEK, AND NOBLE GULCH

The Regional Water Quality Control Board adopted these TMDLs on May 8, 2009.
These TMDLs were approved by:

The State Water Resources Control Board on: July 6, 2010.
The California Office of Administrative Law on: September 5, 2010.
The U.S. Environmental Protection Agency on: November 17, 2010.

Problem Statement

The beneficial use of water contact recreation is not protected in the impaired reaches of Soquel Lagoon, Soquel Creek, and Noble Gulch because fecal coliform concentrations exceed water quality objectives protecting this beneficial use. The impaired reaches are:

1) Soquel Lagoon and Soquel Creek: beginning from the mouth of Soquel Lagoon, upstream and along Soquel Creek to the bridge at Porter Street.
2) All reaches of Noble Gulch.

Numeric Targets

The numeric targets used to develop the TMDLs and allocations are as follows:

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

Source Analysis

The controllable sources of fecal coliform contributing to impairment in Soquel Lagoon, Soquel Creek, and Noble Gulch are, in decreasing order of contribution:

1. Storm drain discharges to municipally owned and operated separate storm sewer systems (MS4s) required to be covered by an NPDES permit (including but not limited to discharges of fecal material from domestic animals and humans).
2. Sanitary sewer collection system spills and leaks (including but not limited to discharges from private laterals connected to municipal sanitary sewer collection systems).
3. Domestic animal waste discharges in areas that do not drain to MS4s (including but not limited to farm animals, livestock and pets).
4. Homeless person/encampment discharges in areas that do not drain to MS4s.

Total Maximum Daily Load (TMDL)

The TMDLs for the impaired reaches of the following water bodies are concentration based TMDLs applicable for each day for all seasons and are equal to the following:

Soquel Lagoon, Soquel Creek, and Noble Gulch:

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

Allocations and Responsible Parties

The allocations to responsible parties are shown in Table IX K-1.

Table IX K-1. Allocations to Responsible Parties

Waste Load Allocations		
Waterbody Subject to Allocation	**Responsible Party (Source) NPDES/ORDER Number**	**Receiving Water Fecal Coliform (MPN/100mL)**
Soquel Lagoon[1]	City of Capitola (Storm drain discharges to MS4s required to be covered by an NPDES permit) Storm Water General Permit NPDES No. CAS000004	Allocation-1[a]
Soquel Creek [2] Noble Gulch[3]	County of Santa Cruz and City of Capitola (Storm drain discharges to MS4s required to be covered by an NPDES permit) Storm Water General Permit NPDES No. CAS000004	Allocation-1[a]
Soquel Lagoon[1] Soquel Creek [2] Noble Gulch[3]	Santa Cruz County Sanitation District (Sanitary sewer collection system spills and leaks) Order No. R3-2005-0043	Allocation-2[b]
Load Allocations		
Waterbody Subject to Allocation	**Responsible Party (Source)**	**Receiving Water Fecal Coliform (MPN/100mL)**
Soquel Lagoon[1] Soquel Creek [2] Noble Gulch[3]	Owners and operators of land used for/containing pets (Pet waste not draining to MS4s)	Allocation-1[a]
Noble Gulch[3]	Owners and operators of land used for/containing farm animals and livestock (Farm Animals and Livestock discharges)	Allocation-1[a]
Soquel Lagoon[1] Soquel Creek [2] Noble Gulch[3]	Owners/operators of land that include homeless persons/encampments (Homeless person/encampment discharges not draining to MS4s)	Allocation-2[b]
Soquel Lagoon[1] Soquel Creek [2] Noble Gulch[3]	No responsible party (Natural sources)	Allocation-1[a]

1 All waters of the Soquel Lagoon.
2 Beginning and including the downstream most reach of Soquel Creek, up to and including Soquel Creek at the bridge crossing at Porter Street.

3 All reaches of Noble Gulch.

a Allocation-1: Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

b Allocation 2: Allocation of zero; no loading allowed from this source.

The parties responsible for the allocations to controllable sources are not responsible for the allocation to natural sources.

The TMDLs are considered achieved when the numeric target is consistently met in the impaired waters of Soquel Lagoon, Soquel Creek, and Noble Gulch.

Margin of Safety

A margin of safety is incorporated implicitly in the TMDLs through conservative assumptions.

Implementation Plan

STORM DRAIN DISCHARGES:

The Central Coast Water Board will address fecal indicator bacteria (FIB), e.g., fecal coliform and/or other indicators of pathogens, discharged from the County of Santa Cruz and the City of Capitola by regulating the MS4 entities under the provisions of the State Water Resources Control Board's General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems (General Permit) (NPDES No. CAS000004). As enrollees under the General Permit, the MS4 entities must develop and implement Storm Water Management Plans (SWMPs) that control urban runoff discharges into and from their MS4s. To address the MS4 entities' TMDL wasteload allocations, the Central Coast Water Board will require the MS4 entities to specifically target FIB in urban runoff through incorporation of Wasteload Allocation Attainment Programs in their SWMPs.

The Central Coast Water Board will require the Wasteload Allocation Attainment Programs to include descriptions of the actions that will be taken by the MS4 entities to attain the TMDL wasteload allocations, and specifically address:

1. Development of an implementation and assessment strategy;
2. Source identification and prioritization (including leaks to storm sewers from private laterals);
3. Best management practice identification, prioritization, implementation schedule, analysis, and effectiveness assessment;
4. Monitoring program development and implementation;
5. Reporting; including evaluation whether current best management practices are progressing towards achieving the wasteload allocations within thirteen years of the date that the TMDLs are approved by the Office of Administrative Law;
6. Coordination with stakeholders; and
7. Other pertinent factors.

The Wasteload Allocation Attainment Program will be required by the Central Coast Water Board to address each of these TMDLs that occur within the MS4 entities' jurisdictions.

The Central Coast Water Board will require the Wasteload Allocation Attainment Program to be submitted at one of the following milestones, whichever occurs first:

1. Within one year of approval of the TMDLs by the Office of Administrative Law;
2. When required by any other Water Board-issued storm water requirements (e.g., when the Phase II Municipal Storm Water Permit is renewed).

For those MS4 entities that are enrolled under the General Permit at the time of Wasteload Allocation Attainment Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMPs when they are submitted. For those MS4 entities that are not enrolled under the General Permit at the time of Wasteload Allocation Attainment Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMPs when the SWMPs are approved by the Central Coast Water Board.

The Executive Officer or the Central Coast Water Board will require information that demonstrates implementation of the actions described above, pursuant to applicable sections of the California Water Code and/or pursuant to authorities provided in the General Permit for storm water discharges.

SANITARY SEWER COLLECTION SYSTEM SPILLS AND LEAKS:

Entities with jurisdiction over sewer collection systems can demonstrate compliance with these TMDL load allocations through Waste Discharge Requirements and/or NPDES permits.

The Santa Cruz County Sanitation District (SCCSD) must continue to implement their Collection System Management Plan, as required by Waste Discharge Requirements (WDRs) (Order No. R3-2005-0043).

In addition, the SCCSD is required to improve maintenance of their sewage collection system, including identification, correction, and prevention of sewage leaks in portions of the collection systems that run through, or adjacent to, impaired surface waters within the Soquel Lagoon Watershed.

To this end, within six months following approval of these TMDLs by the Office of Administrative Law, the Executive Officer will issue a letter pursuant to Section 13267 of the California Water Code requiring: 1) submittal within one year of a technical report that describes how and when the SCCSD will conduct improved collection system maintenance in portions of the collection system most likely to affect impaired surface water bodies, with the end result being compliance with its TMDL allocation, 2) stream monitoring for fecal coliform or another fecal indicator bacteria and reporting of these monitoring activities, and 3) annual reporting of self-assessment as to whether the SCCSD is in compliance with the TMDL allocation.

PRIVATE LATERALS TO THE SANITARY SEWER COLLECTION SYSTEM:

The Central Coast Water Board has identified leaks from private laterals located in the City of Capitola and County of Santa Cruz as a source of fecal indicator bacteria in Municipal Separate Storm Sewer Systems (MS4s). Therefore, enrollees for the City of Capitola and County of Santa Cruz General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems will address fecal indicator bacteria from private lateral leaks in the Wasteload Allocation Attainment Program (as described in the Storm Drain Discharges section).

DOMESTIC ANIMALS NOT REGULATED BY WQ ORDER NO. 2003-0005-DWQ [STORM WATER GENERAL PERMIT]:

Owners and/or operators of lands containing domestic animals (including pets, farm animals, and livestock) in the Soquel Lagoon Watershed must comply with the Domestic Animal Waste Discharge Prohibition; compliance with the Domestic Animal Waste Discharge Prohibition implies compliance with the load allocation for these TMDLs.

Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will notify owners and/or operators of lands used for/containing domestic animals of the requirement to comply with the Domestic Animal Waste Discharge Prohibition. In his notification, the Executive Officer will also describe the options owners/operators of lands containing domestic animals have for demonstrating compliance with the Domestic Animal Waste Discharge Prohibition. Pursuant to California Water Code section 13267 and within six months of the notification by the Executive Officer, owners/operators of lands containing domestic animals will be required to submit one of the following for approval by the Executive Officer or the Central Coast Water Board:

1) Clear evidence that the owner/operator of lands containing domestic animals is and will continue to be in compliance with the Domestic Animal Waste Discharge Prohibition; clear evidence could be documentation submitted by the owner/operator to the Executive Officer validating current and continued compliance with the Prohibition.
2) A plan for compliance with the Domestic Animal Waste Discharge Prohibition. Such a plan must include a list of specific management practices that will be implemented to control discharges containing fecal material from domestic animals. The plan must also describe how implementing the identified management practices are likely to progressively achieve the load allocations to domestic animals, with the ultimate goal of achieving the load allocations no later than thirteen years after Office of Administrative Law approval of these TMDLs. The plan must include monitoring and reporting to the

Central Coast Water Board, demonstrating the progress towards achieving load allocations for discharges from domestic animals, and a self-assessment of this progress. The plan may be developed by an individual discharger or by or for a coalition of dischargers in cooperation with a third-party representative, organization, or government agency acting as the agents of owners/operators of lands containing domestic animals.

3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements).

HOMELESS PERSON/ENCAMPMENT DISCHARGES NOT REGULATED BY WQ ORDER NO. 2003-0005-DWQ [STORM WATER GENERAL PERMIT:

Owners of land that contain homeless persons and/or homeless encampments in the Soquel Lagoon Watershed must comply with the Human Fecal Material Discharge Prohibition.

Owners of land with homeless persons must demonstrate to the satisfaction of the Executive Officer or the Central Coast Water Board that they are in compliance with the Human Fecal Material Discharge Prohibition; compliance with the Human Fecal Material Discharge Prohibition implies compliance with the load allocation for these TMDLs.

Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will notify owners of land containing homeless persons of the requirement to comply with the Human Fecal Material Discharge Prohibition. In his notification, the Executive Officer will also describe the options owners have for demonstrating compliance with the Human Fecal Material Discharge Prohibition. Pursuant to California Water Code 13267 and within six months of the notification by the Executive Officer, owners will be required to submit one of the following for approval by the Executive Officer or the Central Coast Water Board:

1) Clear evidence that the owner is and will continue to be in compliance with the Human Fecal Material Discharge Prohibition; clear evidence could be documentation submitted by the owner to the Executive Officer validating current and continued compliance with the Prohibition.
2) A plan for compliance with the Human Fecal Material Discharge Prohibition. Such a plan must include a list of specific management practices that will be implemented to control discharges containing fecal material from homeless persons. The Plan must also describe how implementing the identified management practices are likely to progressively achieve the load allocation for homeless persons, with the ultimate goal of achieving the load allocation no later than three years from the date of the Executive Officer's notification to the owner requiring compliance. The plan must include monitoring and reporting to the Central Coast Water Board, demonstrating the progress towards achieving load allocations for discharges from homeless persons, and self-assessment of this progress.
3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements).

Tracking and Evaluation

Every three years, beginning three years after TMDLs are approved by the Office of Administrative Law, the Central Coast Water Board will perform a review of implementation actions, monitoring results, and evaluations submitted by responsible parties of their progress towards achieving their allocations. The Central Coast Water Board will use annual reports, nonpoint source pollution control implementation programs, evaluations submitted by responsible parties, and other available information to determine progress toward implementing required actions and achieving the allocations and the numeric target.

Responsible parties will continue monitoring and reporting according to this plan for at least three years, at which time the Central Coast Water Board will determine the need for continuing or otherwise modifying the monitoring requirements. Responsible parties may also demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pathogens are not contributing to the exceedance. If this is the case, the Central Coast Water Board may re-evaluate the numeric target and allocations. For example, the Central Coast Water Board may pursue and approve a site-specific objective. The site-specific objective would be based on evidence that natural or background sources alone were the cause of exceedances of the Basin Plan water quality objective for fecal indicator bacteria.

Three-year reviews will continue until the water quality objectives are achieved. The compliance schedule for achieving the allocations and numeric target required under these TMDLs is 13 years after the date of approval by the Office of Administrative Law.

IX. L. TOTAL MAXIMUM DAILY LOADS FOR PATHOGENS IN APTOS CREEK, VALENCIA CREEK, AND TROUT GULCH

The Regional Water Quality Control Board adopted these TMDLs on May 8, 2009.
These TMDLs were approved by:

The State Water Resources Control Board on August 3, 2010.
The California Office of Administrative Law on October 29, 2010.
The U.S. Environmental Protection Agency on January 20, 2011.

Problem Statement

The beneficial use of water contact recreation is not being attained in Aptos Creek, Valencia Creek and Trout Gulch because fecal coliform concentrations exceed existing Basin Plan numeric water quality objectives protecting this beneficial use. Staff concluded Aptos Creek was impaired below the confluence with Valencia Creek. The entire reach of Trout Gulch was considered impaired. Staff also considered Valencia Creek impaired from its confluence with Aptos Creek, upstream to both the east and west forks. The east fork was impaired upstream to the intersection of McKay and Cox Roads. The west fork was impaired upstream to its intersection with Valencia Road.

Numeric Targets

The numeric targets used to develop the TMDLs and allocations are as follows:

> Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

Source Analysis

The relative order of controllable sources, in descending order, contributing pathogens to Aptos Creek, Valencia Creek, and Trout Gulch are: (1) storm drain discharges to municipally owned and operated separate storm sewer systems (MS4s) required to be covered by an NPDES permit, (2) pet waste in areas that do not drain to MS4s, (3) County of Santa Cruz Sanitation District sanitary sewer collection system spills and leaks, (4) private sewer laterals connected to municipal sanitary sewer collection systems, and (5) farm animals and livestock discharges.

TMDLs and Allocations

The TMDLs for all impaired waters of Aptos Creek, Valencia Creek, and Trout Gulch are concentration based TMDLs applicable to each day of all seasons and are equal to the following:

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

The allocations to responsible parties are shown in Table IX-L-1.

Table IX – L - 1. Allocations and Responsible Parties

WASTE LOAD ALLOCATIONS		Receiving Water Fecal Coliform (MPN/100mL)
Waterbody	**Responsible Party** **(Source)** **NPDES/Order number**	
Aptos Creek[1], Trout Gulch[2], Valencia Creek[3]	Santa Cruz County (Storm drain discharges to MS4s required to be covered by an NPDES permit) Storm Water General Permit NPDES No. CAS000004	Allocation 1[a]
Aptos Creek[1], Trout Gulch[2], Valencia Creek[3]	Santa Cruz County Sanitation District (Sanitary sewer collection system spills and leaks) Order No. R3-2005-0043	Allocation 2[b]
LOAD ALLOCATIONS		**Receiving Water Fecal Coliform (MPN/100mL)**
Waterbody	**Responsible Party (Source)**	
Aptos Creek[1], Trout Gulch[2], Valencia Creek[3]	Owners/Operators of land used for/containing pets (Pet waste not draining to MS4s)	Allocation 1[a]
Aptos Creek[1], Trout Gulch[2], Valencia Creek[3]	Owners/Operators of land used for/containing farm animals and livestock (Farm Animals and Livestock discharges)	Allocation 1[a]
Aptos Creek[1], Trout Gulch[2], Valencia Creek[3]	Natural sources	Allocation 1[a]

1 Aptos Creek from the Pacific Ocean to the confluence of Aptos and Valencia Creeks
2 All reaches of Trout Gulch
3 Valencia Creek from the confluence with Aptos Creek upstream to the west fork, where it intersects with Valencia Road, and to the east fork at the intersection of McKay and Cox Roads.

a Allocation 1: Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN/100mL, nor shall more than ten percent of total samples during any 30-day period exceed 400 MPN/100 mL.

b Allocation 2: Allocation of zero; no loading allowed from this source.

The parties responsible for the allocations to controllable sources are not responsible for the allocation to natural sources.

The TMDLs are considered achieved when the allocations assigned to all individual responsible parties are met, or when the numeric targets are consistently met in Aptos Creek, Valencia Creek, and Trout Gulch.

Margin of Safety

A margin of safety is incorporated implicitly in the TMDLs through conservative assumptions.

Implementation Plan

STORM DRAIN DISCHARGES

The Central Coast Water Board will address fecal indicator bacteria (FIB), e.g. fecal coliform and/or other indicators of pathogens, discharged from the County of Santa Cruz' municipal separate storm sewer system (MS4) by regulating the MS4 under the provisions of the State Water Resources Control Board's General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems (General Permit) (NPDES No. CAS000004). As an enrollee under the General Permit, the MS4 must develop and implement a Storm Water Management Plan (SWMP) that controls urban runoff discharges into and from its MS4. To address the MS4's TMDL wasteload allocations, the Central Coast Water Board will require the MS4 to specifically target FIB in urban runoff through incorporation of a Wasteload Allocation Attainment Program in its SWMP.

The Central Coast Water Board will require the Wasteload Allocation Attainment Program to include descriptions of the actions that will be taken by the MS4 to attain the TMDL wasteload allocations, and specifically address:

1. Development of an implementation and assessment strategy;
2. Source identification and prioritization (including leaks to storm sewers from private laterals);
3. Best management practice identification, prioritization, implementation schedule, analysis, and effectiveness assessment;
4. Monitoring program development and implementation;
5. Reporting, including evaluation whether current best management practices are progressing towards achieving the wasteload allocations within thirteen years of the date that the TMDLs are approved by the Office of Administrative Law;
6. Coordination with stakeholders; and
7. Other pertinent factors.

The Wasteload Allocation Attainment Program will be required by the Central Coast Water Board to address each of these TMDLs that occur within the MS4 entity's jurisdiction.

The Central Coast Water Board will require the Wasteload Allocation Attainment Program to be submitted at one of the following milestones, whichever occurs first:

1. Within one year of approval of the TMDLs by the Office of Administrative Law;
2. When required by any other Water Board-issued storm water requirements (e.g., when the Phase II Municipal Storm Water Permit is renewed).

For an MS4 that is enrolled under the General Permit at the time of Wasteload Allocation Attainment Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMPs when they are submitted. For an MS4 that is not enrolled under the General Permit at the time of Wasteload Allocation Attainment Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMP when the SWMP is approved by the Central Coast Water Board.

The Executive Officer or the Central Coast Water Board will require information that demonstrates implementation of the actions described above, pursuant to applicable sections of the California Water Code and/or pursuant to authorities provided in the General Permit for storm water discharges.

SANITARY SEWER COLLECTION SYSTEM SPILLS AND LEAKS

Entities with jurisdiction over sewer collection systems can demonstrate compliance with these TMDL allocations through waste discharge requirements and/or NPDES permits.

The Santa Cruz County Sanitation District (SCCSD) must continue to implement its Collection System Management Plan, as required by Waste Discharge Requirements (WDRs) (Order No. R3-2005-0043).

In addition, the SCCSD is required to improve maintenance of their sewage collection system, including identification, correction, and prevention of sewage leaks in portions of the collection systems that run through, or adjacent to, impaired surface waters within the Aptos Creek Watershed.

To this end, within six months following approval of these TMDLs by the Office of Administrative Law, the Executive Officer will issue a letter pursuant to Section 13267 of the California Water Code requiring: 1) submittal within one year of a technical report that describes how and when the SCCSD will conduct improved collection system maintenance in portions of the collection system most likely to affect impaired surface water bodies, with the end result being compliance with its TMDL allocation, 2) stream monitoring for fecal coliform or another fecal indicator bacteria and reporting of these monitoring activities, and 3) annual reporting of self-assessment as to whether the SCCSD is in compliance with the TMDL allocation.

PRIVATE SEWER LATERAL DISCHARGES

The Central Coast Water Board has identified leaks from private laterals located in the County of Santa Cruz as a source of fecal indicator bacteria in municipal separate storm sewer systems (MS4s). Therefore, enrollees for the County of Santa Cruz' General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems will address fecal indicator bacteria from private lateral leaks in the Wasteload Allocation Attainment Program (as described in the above Storm Drain Discharges section).

PET WASTE, FARM ANIMALS AND LIVESTOCK DISCHARGES

Owners and/or operators of lands containing domestic animals (including pets, farm animals, and livestock) in the Aptos Creek Watershed must comply with the Domestic Animal Waste Discharge Prohibition; compliance with the Domestic Animal Waste Discharge Prohibition implies compliance with the load allocation for these TMDLs.

Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will notify owners and/or operators of lands used for/containing domestic animals of the requirement to comply with the Domestic Animal Waste Discharge Prohibition. In his notification, the Executive Officer will also describe the options owners/operators of lands containing domestic animals have for demonstrating compliance with the Domestic Animal Waste Discharge Prohibition. Pursuant to California Water Code section 13267 and within six months of the notification by the Executive Officer, owners/operators of lands containing domestic animals will be required to submit one of the following for approval by the Executive Officer or the Central Coast Water Board:

1) Clear evidence that the owner/operator of lands containing domestic animals is and will continue to be in compliance with the Domestic Animal Waste Discharge Prohibition; clear evidence could be documentation submitted by the owner/operator to the Executive Officer validating current and continued compliance with the Prohibition.
2) A plan for compliance with the Domestic Animal Waste Discharge Prohibition. Such a plan must include a list of specific management practices that will be implemented to control discharges containing fecal material from domestic animals. The plan must also describe how implementing the identified management practices are likely to progressively achieve the load allocations to domestic animals, with the ultimate goal of achieving the load allocations no later than thirteen years after Office of Administrative Law approval of these TMDLs. The plan must include monitoring and reporting to the Central Coast Water Board, demonstrating the progress toward achieving load allocations for discharges from domestic animals, and a self-assessment of this progress. The plan may be developed by an individual discharger or by or for a coalition of dischargers in cooperation with a third-party representative, organization, or government agency acting as the agents of owners/operators of lands containing domestic animals.
3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements).

Tracking and Evaluation

Every three years, beginning three years after TMDLs are approved by the Office of Administrative Law, the Central Coast Water Board will perform a review of implementation actions, monitoring results, and evaluations submitted by responsible parties of their progress toward achieving their allocations. The Central Coast Water

Board will use annual reports, nonpoint source pollution control implementation programs, evaluations submitted by responsible parties, and other available information to determine progress toward implementing required actions and achieving the allocations and the numeric target.

Responsible parties will continue monitoring and reporting according to this plan for at least three years, at which time the Central Coast Water Board will determine the need for continuing or otherwise modifying the monitoring requirements. Responsible parties may also demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pathogens are not contributing to the exceedance. If this is the case, the Central Coast Water Board may re-evaluate the numeric target and allocations. For example, the Central Coast Water Board may pursue and approve a site-specific objective, based on evidence that natural or background sources alone were the cause of exceedances of the Basin Plan water quality objective for fecal indicator bacteria.

Three-year reviews will continue until the water quality objectives are achieved. The compliance schedule for achieving this TMDL numeric target is 13 years after the date of approval by the Office of Administrative Law.

IX. M. TOTAL MAXIMUM DAILY LOADS FOR FECAL COLIFORM IN PAJARO RIVER WATERSHED WATERS (INCLUDING PAJARO RIVER, SAN BENITO RIVER, LLAGAS CREEK, TEQUISQUITA SLOUGH, SAN JUAN CREEK, CARNADERO/UVAS CREEK, BIRD CREEK, PESCADERO CREEK, TRES PINOS CREEK, FURLONG (JONES) CREEK, SANTA ANA CREEK, AND PACHECO CREEK)

The Regional Water Quality Control Board adopted these TMDLs on March 20, 2009.
These TMDLs were approved by:

The State Water Resources Control Board on April 20, 2010.
The California Office of Administrative Law on July 12, 2010.
The U.S. Environmental Protection Agency on August 3, 2010.

Problem Statement

The beneficial use of water contact recreation is not being protected in Pajaro River Watershed (including the following water bodies: Pajaro River, San Benito River, Llagas Creek, Tequisquita Slough, San Juan Creek, Carnadero/Uvas Creek, Bird Creek, Pescadero Creek, Tres Pinos Creek, Furlong (Jones) Creek, Santa Ana Creek, and Pacheco Creek) because fecal coliform concentrations exceed Basin Plan numeric water quality objectives designed to protect this beneficial use.

Numeric Target

Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

Source Analysis

The relative order of controllable sources contributing fecal coliform in the Pajaro River Watershed, in decreasing order of contribution are: (1) storm drain discharges to municipally owned and operated storm sewer systems required to be covered by an NPDES permit (MS4s); (2) domestic animal discharges that do not discharge to MS4s; (3) spills and leaks from Sanitary Sewer Collection and Treatment Systems; and (4) private sewer laterals connected to municipal sanitary sewer collection systems. Natural, uncontrollable sources also contribute fecal coliform in the Pajaro River Watershed.

TMDLs and Allocations

The TMDLs for the impaired waters of Pajaro River, San Benito River, Llagas Creek, Tequisquita Slough, San Juan Creek, Carnadero/Uvas Creek, Bird Creek, Pescadero Creek, Tres Pinos Creek, Furlong (Jones) Creek, Santa Ana Creek, and Pacheco Creek are concentration-based TMDLs applicable to each day of all seasons equal to the following:

> Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than 10 percent of samples collected during any 30-day period exceed 400 MPN per 100 mL.

The allocations to responsible parties are shown in Table IX-M1.

Table IX – M - 1. Allocations and Responsible Parties

Waterbody Assigned Allocation	Responsible Party [NPDES and/or WDR number] (Source)	Receiving Water Fecal Coliform Allocation
WASTE LOAD ALLOCATIONS		
Pajaro River[1] San Benito River[2] Llagas Creek[3] Tequisquita Slough[4]	Santa Cruz, Santa Clara, and Monterey Counties. Cities of Hollister, Morgan Hill, Gilroy, and Watsonville [NPDES No. CAS000004] (Storm Drain Discharges To MS4s Required to be covered by an NPDES Permit)	Allocation 1
Pajaro River[1] San Benito River[2] Llagas Creek[3] Tequisquita Slough[4]	City of Hollister [WDR 87-47] (Sanitary Sewer Collection and Treatment Systems Spills and Leaks) City of Watsonville [WDR Order R3-2003-0040, NPDES No. CA0048216] (Sanitary Sewer Collection and Treatment Systems Spills and Leaks) Cities of Gilroy and Morgan Hill via South County Regional Wastewater Authority (SCRWA) [WDR Order R3-2004-0099, NPDES No. CA0049964] (Sanitary Sewer Collection and Treatment Systems Spills and Leaks) San Juan Bautista Wastewater Treatment Facility [WDR Order R3-2003-0087, NPDES No. CA0047902] (Sanitary Sewer Collection and Treatment Systems Spills and Leaks) Sunnyslope County Water District [WDR Order R3-2004-0065] (Sanitary Sewer Collection and Treatment Systems Spills and Leaks) Tres Pinos County Water District [WDR Order 99-101] (Sanitary Sewer Collection and Treatment Systems Spills and Leaks) Pajaro County Sanitation District [WDR Order R3-2003-0041] (Sanitary Sewer Collection and Treatment Systems Spills and Leaks)	Allocation 2
Pajaro River[1] San Benito River[2] Llagas Creek[3] Tequisquita Slough[4]	Owners of Private Sewer Laterals (Private Laterals Connected to Municipal Sanitary Sewer Collection and Treatment Systems)	Allocation 2
LOAD ALLOCATIONS		
Waterbody	**Responsible Party (Source)**	
Pajaro River[1] San Benito River[2] Llagas Creek[3] Tequisquita Slough[4]	Owners/Operators of Land Used for/Containing Domestic Animals (Domestic Animal Discharges)	Allocation 1
Pajaro River[1] San Benito River[2] Llagas Creek[3] Tequisquita Slough[4]	Natural Sources	Allocation 1

Allocation 1: Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200/100mL, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 mL.

Allocation 2: Allocation of zero; no loading allowed from this source.

1 The entire Pajaro River from the Pacific Ocean to San Felipe Lake outflow via the Miller's Canal drain. Including the entire San Juan Creek tributary from the uppermost reach of the waterbody to the confluence with Pajaro River, and Carnadero/Uvas Creek tributary from Hollister Road crossing to the confluence with Pajaro River.

2 San Benito River from confluence with Pajaro River to three miles above Old Hernandez Road at Arizona Crossing. Including Bird Creek tributary from the uppermost reach of the waterbody to the confluence with San Benito River, the Pescadero Creek tributary from the uppermost reach of the waterbody to the confluence with San Benito River, and Tres Pinos Creek tributary from the uppermost reach of the waterbody to the confluence with San Benito River.

3 Llagas Creek from confluence with Pajaro River to Oak Glen Avenue. Including Furlong (Jones) Creek tributary from the uppermost reach of the waterbody to confluence with Llagas Creek.

4 Tequisquita Slough from confluence with San Felipe Lake to the uppermost reach of the waterbody. Including Santa Ana Creek tributary from the uppermost reach of the waterbody to Tequisquita Slough, and Pacheco Creek tributary from the uppermost reach of the waterbody to San Felipe Lake.

The parties responsible for the allocations to controllable sources are not responsible for the allocation to natural sources.

The TMDLs are considered achieved when the allocations assigned to all individual responsible parties are met, or when the numeric targets are consistently met.

Margin of Safety

A margin of safety is incorporated implicitly in the TMDLs through conservative assumptions.

Implementation Program

MUNICIPAL SEPARATE STORM SEWER SYSTEM DISCHARGES

The Central Coast Water Board will address fecal indicator bacteria (FIB), e.g. fecal coliform and/or other indicators of pathogens, discharged from the Counties of Santa Cruz, Santa Clara, and Monterey, and the Cities of Hollister, Gilroy, Morgan Hill, and Watsonville municipal separate storm sewer systems (MS4 entities) by regulating the MS4 entities under the provisions of the State Water Resource Control Board's General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems (General Permit) (NPDES No. CAS000004). As enrollees under the General Permit, the MS4 entities must develop and implement Storm Water Management Program (SWMPs) that control urban runoff discharges into and from their MS4s. To address the MS4 entities' TMDL wasteload allocations, the Central Coast Water Board will require the MS4 entities to specifically target FIB in urban runoff through incorporation of Wasteload Allocation Attainment Program in their SWMPs.

The Central Coast Water Board will require the Wasteload Allocation Attainment Program describe the actions that will be taken by the MS4 entities to attain the TMDL wasteload allocations, and specifically address:

1. Development of an implementation and assessment strategy;
2. Source identification and prioritization;
3. Best management practice identification, prioritization, implementation, analysis, and effectiveness assessment;
4. Monitoring program development and implementation;
5. Reporting; including evaluation whether current best management practices are progressing towards achieving the wasteload allocations by thirteen years after the TMDLs are approved by the Office of Administrative Law.
6. Coordination with stakeholders; and
7. Other pertinent factors.

The Wasteload Allocation Attainment Program will be required by the Central Coast Water Board to address each of these TMDLs that occur within the MS4 entities' jurisdictions.

The Central Coast Water Board will require the Wasteload Allocation Attainment Program to be submitted at one of the following milestones, whichever occurs first:

1. Within one year of approval of the TMDLs by the Office of Administrative Law;
2. When required by any other Water Board-issued storm water requirements (e.g., when the Phase II Municipal Storm Water Permit is renewed).

For an MS4 that is enrolled under the General Permit at the time of Wasteload Allocation Attainment Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMP when the Wasteload Allocation Attainment Program is submitted. For an MS4 entity that is not enrolled under the General Permit at the time of the Wasteload Allocation Program submittal, the Wasteload Allocation Attainment Program must be incorporated into the SWMP when the SWMP is approved by the Central Coast Water Board.

The Executive Officer or the Central Coast Water Board will require information that demonstrates implementation of the actions described above, pursuant to applicable sections of the California Water Code and/or pursuant to authorities provided in the General Permit for storm water discharges.

SANITARY SEWER COLLECTION AND TREATMENT SYSTEMS SPILLS AND LEAKS

Entities with jurisdiction over sewer collection systems in the Pajaro River Watershed must comply with the Human Fecal Material Discharge Prohibition; compliance with the Human Fecal Material Discharge Prohibition implies compliance with their load allocation for this TMDL.

To comply with the Human Fecal Material Discharge Prohibition, the Hollister Domestic Wastewater Treatment Facility (WDR Order 87-47), Sunnyslope County Water District, Ridgemark Estates Subdivision, Wastewater Treatment Plant (WDR Order R3-2004-0065), Tres Pinos County Water District (WDR Order 99-101), San Juan Bautista Wastewater Treatment Facility (WDR Order R3-2003-0087, NPDES CA0047902), South County Regional Wastewater Authority (SCRWA), Cities of Gilroy and Morgan Hill, (WDR Order R3-2004-0099, NPDES CA0049964), City of Watsonville Wastewater Treatment Facility (WDR Order R3-2003-0040, NPDES CA0048216), and Pajaro County Sanitation District (WDR Order R3-2003-0041) (herein referred to as sanitary collection system jurisdictions) must continue to implement their Collection System Management Plans, as required by their Waste Discharge Requirements (WDRs) and National Pollutant Discharge Elimination System (NPDES) permits.

In addition, the sanitary collection system jurisdictions identified above and in Table IX-M-1 are required to improve maintenance of their sewage collection systems, including identification, correction, and prevention of sewage leaks in portions of the collection systems that run through or adjacent to, impaired surface waters within the Pajaro River Watershed.

To this end, within six months following adoption of this TMDL by the Office of Administrative Law, the Executive Officer will issue a letter pursuant to Section 13267 of the CWC requiring: 1) submittal within one-year, a technical report that describes how and when the jurisdictions of the collection systems will conduct improved collection system maintenance in portions of the collection system most likely to affect impaired surface water bodies, with the end result being compliance with the Human Fecal Material Discharge Prohibition, and 2) stream monitoring for fecal coliform or another fecal indicator bacteria, and reporting of these monitoring activities, and 3) annual reporting of self-assessment as to whether the sanitary collection system jurisdiction is in compliance with the Human Fecal Material Discharge Prohibition.

PRIVATE SEWER LATERAL DISCHARGES

Individual owners and operators of private laterals to sanitary sewer collection systems are ultimately responsible for maintenance of their private laterals and are, therefore, responsible for complying with the Human Fecal

Material Discharge Prohibition; compliance with the Human Fecal Material Discharge Prohibition implies compliance with their load allocation for these TMDLs.

The Central Coast Water Board requires immediate cessation of spills from private laterals. Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will notify owners and/or operators of private laterals to sanitary sewer collection systems (owners/operators of private laterals), in suspected problem areas, of this requirement and of the requirement to comply with the Human Fecal Material Discharge Prohibition. In his notification, the Executive Officer will also describe the owner's/operator's of private laterals options for demonstrating compliance with the Human Fecal Material Discharge Prohibition; pursuant to California Water Code section 13267 and within six months of the notification by the Executive Officer, owners/operators of private laterals will be required to submit the following for approval by the Executive Officer or the Water Board:

1) Clear evidence that the owner/operator of private lateral is and will continue to be in compliance with the Human Fecal Material Discharge Prohibition; clear evidence could be certification by a sanitary collection system jurisdiction that owner/operator of private lateral is in compliance with the Human Fecal Material Discharge Prohibition, or
2) A schedule for compliance with the Human Fecal Material Discharge Prohibition. The compliance schedule must include a monitoring and reporting program and milestone dates demonstrating progress towards compliance with the Human Fecal Material Discharge Prohibition, with the ultimate milestone being compliance with the Human Fecal Material Discharge Prohibition no later than three years (the exact timeframe at the discretion of the Executive Officer) from the date of the Executive Officer's notification to the owner/operator requiring compliance, or
3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements; WDRs or National Pollutant Discharge Elimination System (NPDES permit)), or
4) Clear evidence of current or scheduled compliance with the Human Fecal Material Discharge Prohibition (as described in number-1 and number-2 above, respectively) through the submittal of the required information by a sanitary collection system jurisdiction, acting as the voluntary agents of owners/operators of private laterals. Note that an owner/operator of a private lateral cannot demonstrate compliance with the Human Fecal Material Discharge Prohibition through this option if: 1) a sanitary collection system jurisdiction is not their voluntary agent, or 2) if the owner/operator of the private lateral does not choose the sanitary collection system jurisdiction as their agent, or, 3) the Executive Officer or Water Board does not approve the evidence submitted by the sanitary collection system jurisdictions on behalf of the owners/operators of private laterals.

DOMESTIC ANIMAL DISCHARGES NOT REGULATED BY A PERMIT FOR STORM WATER DISCHARGES

Owners and/or operators of lands containing domestic animals in the Pajaro River Watershed must comply with the Domestic Animal Waste Discharge Prohibition; compliance with the Domestic Animal Waste Discharge Prohibition implies compliance with the load allocation for these TMDLs.

Within three years of approval of these TMDLs by the Office of Administrative Law, the Executive Officer will notify owners and/or operators of lands used for/containing domestic animals of the requirement to comply with the Domestic Animal Waste Discharge Prohibition. In his notification, the Executive Officer will also describe the owner's/operator's of lands containing domestic animals options for demonstrating compliance with the Domestic Animal Waste Discharge Prohibition; pursuant to California Water Code section 13267 and within six months of the notification by the Executive Officer, owners/operators of lands containing domestic animals will be required to submit the following for approval by the Executive Officer or the Water Board:

1) Clear evidence that the owner/operator of lands containing domestic animals is and will continue to be in compliance with the Domestic Animal Waste Discharge Prohibition; clear evidence could be documentation submitted by the owner/operator to the Executive Officer validating current and continued compliance with the Prohibition, or
2) A plan for compliance with the Domestic Animal Waste Discharge Prohibition. Such a plan must include a list of specific management practices that will be implemented to control discharges containing fecal material from domestic animals. The plan must also describe how implementing the identified management practices is likely to progressively achieve the load allocations to domestic animals, with the ultimate goal achieving the load allocations no later than thirteen years after Office of Administrative Law approval of these TMDLs. The plan must include monitoring and reporting to the Central Coast Water

Board, demonstrating the progressive progress toward achieving load allocations for discharges from domestic animals, and a self-assessment of this progress. The plan may be developed by an individual discharger or by or for a coalition of dischargers in cooperation with a third-party representative, organization, or government agency acting as the agents of owners/operators of lands containing domestic animals, or

3) Submittal of a Report of Waste Discharge pursuant to California Water Code Section 13260 (as an application for waste discharge requirements; WDRs or National Pollutant Discharge Elimination System (NPDES permit).

Tracking and Evaluation

Every three years, beginning three years after TMDLs are approved by the Office of Administrative Law, the Central Coast Water Board will perform a review of implementation actions, monitoring results, and evaluations submitted by responsible parties of their progress towards achieving their allocations. The Central Coast Water Board will use annual reports, nonpoint source pollution control implementation programs, evaluations submitted by responsible parties, and other available information to determine progress toward implementing required actions and achieving the allocations and the numeric target.

Responsible parties will continue monitoring and reporting according to this plan for at least three years, at which time the Central Coast Water Board will determine the need for continuing or otherwise modifying the monitoring requirements. Responsible parties may also demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pathogens are not contributing to the exceedance. If this is the case, the Central Coast Water Board may re-evaluate the numeric target and allocations. For example, the Central Coast Water Board may pursue and approve a site-specific objective. The site-specific objective would be based on evidence that natural, or background sources alone were the cause of exceedances of the Basin Plan water quality objective for fecal indicator bacteria.

Three-year reviews will continue until the water quality objectives are achieved. The compliance schedule for achieving the TMDLs and numeric target is 13 years after the date of approval by the Office of Administrative Law.

CHAPTER 5. PLANS AND POLICIES

In addition to the Implementation Plan, many other plans and policies direct State and Regional Board actions or clarify the Regional Board's intent. The following pages contain brief descriptions of State Board plans and policies and numerous Regional Board plans and policies. Copies of the State and Regional Board policies are contained in the Appendix.

I. STATE WATER RESOURCES CONTROL BOARD PLANS AND POLICIES

The State Water Resources Control Board (State Board) has adopted a number of plans and policies for Statewide water quality management including:

State Policy for Water Quality Control (1972)

Anti-degradation Policy

Thermal Plan

Bays and Estuaries Policy

Power Plant Cooling Policy

Reclamation Policy

Shredder Waste Disposal Policy

Underground Storage Tank Pilot Program

Sources of Drinking Water Policy

Nonpoint Source Management Plan

Ocean Plan

Discharges of Municipal Solid Waste Policy

Should any of these policies be amended by the State Board, the Regional Board will implement the amended version.

The following sections summarize the adopted policy. The complete policy is available in the "Attachments" section of this document.

I.A. STATE POLICY FOR WATER QUALITY CONTROL

The State Board has developed a set of twelve general principles to implement the provisions and intent of the Porter-Cologne Act. These principles, listed below, are contained in a document called the State Policy for Water Quality Control, adopted on July 6, 1972.

1. Water rights and quality control decisions must assure protection of fresh and marine waters for maximum beneficial use.

2. Wastewaters must be considered a part of the total available fresh water resource.

3. Management of supplies and wastewaters shall be on a regional basis for efficient utilization of the resource.

4. Efficient wastewater management requires a balanced program of source control of hazardous substances, treatment, reuse and proper disposal of effluents and residuals.

5. Substances not amenable to removal in treatment plants must be prevented from entering the system.

6. Treatment systems must provide sufficient removals to protect beneficial uses and aquatic communities.

7. Institutional and financial programs of consolidated systems must serve each area equitably.

8. Sewerage facilities must be consolidated for long-range economic and water quality benefits.

9. Reclamation and reuse for maximum benefit shall be encouraged.

10. Systems must be designed and operated for maximum benefit from expended funds.

11. Control methods must be based on the latest information.

12. Monitoring programs must be provided.

I.B. ANTI-DEGRADATION POLICY

On October 28, 1968, the State Water Resources Control Board adopted Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California." While requiring continued maintenance of existing high quality waters, the policy provides conditions under which a change in water quality is allowable. A change must:

1. be consistent with maximum benefit to the people of the State;

2. not unreasonably affect present and anticipated beneficial uses of water; and

3. not result in water quality less than that prescribed in water quality control plans or policies.

I.C. THERMAL PLAN

The "Water Quality Control Plan for the Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California," adopted by the State Water Resources Control Board on May 18, 1972, and amended September 18, 1975, specifies water quality objectives, effluent quality limits, and discharge prohibitions related to thermal characteristics of enclosed bay and estuary waters and waste discharges.

I.D. BAYS AND ESTUARIES POLICY

The "Water Quality Control Policy for the Enclosed Bays and Estuaries of California," Resolution No. 74-43, was adopted by the State Water Resources Control Board on May 16, 1974. Commonly referred to as the "Bays and Estuaries Policy," it was adopted specifically to provide water quality principles and guidelines for the affected waters.

Decisions by the Regional Boards are required to be consistent with the provisions designed to prevent water quality degradation and to protect beneficial uses. The policy lists principles of management that include a statement of the desirability of phasing out all discharges (exclusive of cooling waters) as soon as practicable. Quality requirements state conformability with other plans and policies. Discharge prohibitions are placed on:

1. new dischargers (other than those that would enhance the receiving waters);

2. untreated waste and waste products;

3. refuse;

4. consequential effects of mining, construction, agriculture, and timber harvesting;

5. materials of petroleum origin;

6. radiological, chemical, or high-level radioactive waste; or

7. discharge or by-pass of untreated waste.

I.E. POWER PLANT COOLING POLICY

The "Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Power Plant Cooling" indicates the State Board's position on power plant cooling, specifying that fresh inland waters should be used for cooling only when other alternatives are environmentally undesirable or economically unsound.

I.F. RECLAMATION POLICY

The "Policy with Respect to Water Reclamation in California" requires the Regional Boards to conduct reclamation surveys and specifies reclamation actions to be implemented by the State and Regional Boards as well as other agencies.

I.G. SHREDDER WASTE DISPOSAL POLICY

The "Policy on the Disposal of Shredder Waste" designates specific conditions to be enforced by the Regional Board by which mechanically destructed car bodies, old appliances, or other similar castoffs can be disposed at certain landfills.

I.H. UNDERGROUND STORAGE TANK PILOT POLICY

The "Policy Regarding the Underground Storage Tank Pilot Program" implements a pilot program to fund oversight of remedial action at leaking underground storage tank sites, in cooperation with the California Department of Health Services. Oversight may be deferred to the Regional Boards.

I.I. SOURCES OF DRINKING WATER POLICY

The "Sources of Drinking Water" policy specifies which ground and surface waters are considered to be suitable or potentially suitable for the beneficial use of water supply (MUN). It allows the Regional Board some discretion in making MUN determinations.

I.J. NONPOINT SOURCE MANAGEMENT PLAN

The "Nonpoint Source Management Plan", Resolution 88-123, was adopted by the State Water Resources Control Board on November 15, 1988 pursuant to Section 319 of the Clean Water Act. The Plan identifies nonpoint source control programs and milestones for their accomplishment. It emphasizes cooperation with

local governments and other agencies to promote the implementation of Best Management Practices and remedial projects.

I.K. OCEAN PLAN

The "Water Quality Control Plan for Ocean Waters of California," Resolution No. 90-27 was adopted by the State Water Resources Control Board on March 22, 1990. This plan establishes beneficial uses and water quality objectives for waters of the Pacific Ocean adjacent to the California Coast outside of enclosed bays, estuaries, and coastal lagoons. Also, the Ocean Plan prescribes effluent quality requirements and management principles for waste discharges and specifies certain waste discharge prohibitions.

The Ocean Plan also provides that the State Water Resources Control Board shall designate Areas of Special Biological Significance (ASBS) and requires wastes to be discharged a sufficient distance from these areas to assure maintenance of natural water quality conditions.

The State Water Resources Control Board declared its intent to periodically revise the Plan to reflect water quality objectives that are necessary to protect beneficial uses of ocean waters and to be consistent with current technology.

I.L. DISCHARGES OF MUNICIPAL SOLID WASTE POLICY

The "Policy for Regulation of Discharges of Municipal Solid Waste", Resolution No. 93-62, was adopted by the State Water Resources Control Board on June 17, 1993. This policy implements State regulations of waste discharge to land (California Code of Regulations, Title 23, Chapter 15) and Federal Regulations related to municipal solid waste disposal (40 Code of Federal Regulations Sections 257 and 258). The policy directs Regional Water Quality Control Boards to revise or adopt, prior to the Federal deadline (currently October 9, 1993), Waste Discharge Requirements for all municipal solid waste landfills subject to State and federal regulations. A detailed description of this policy is provided in Chapter Four under the Resources Conservation and Recovery Act section.

II. RECOMMENDED STATE WATER RESOURCES CONTROL BOARD CONTROL ACTIONS

1. State policies for surface waters and for bays and estuaries should be further considered in light of the revised Ocean Plan of 1988.

2. State policies for water quality control should place increasing emphasis on water quality monitoring to determine compliance with water quality objectives in order to provide a firm basis for classification of receiving waters relative to Section 303(e) of Public Law 92-500.

3. Erosion and sedimentation control policies should be established based on (a) pilot studies conducted by the U. S. Soil Conservation Service which recommended best management practices for erosion problems, (b) a statewide study by the California Association of Resource Conservation Districts on institutional solutions to sedimentation problems, and (c) findings of erosion studies conducted in the Central Coast Region as part of nondesignated area 208 planning.

4. Land use planning relative to nonpoint pollution sources should be considered as a future activity, possibly as a multiagency effort; initial control efforts and means for effective control should be from local agencies.

5. Water quality control programs should continue to include emphasis on total water management in order to permit enhancement of naturally degraded surface and ground waters.

6. The State Water Resources Control Board should consider water quality effects when reviewing water rights permits.

7. Policies affecting water rights should reinforce water quality goals particularly as related to long-term ground water salinity changes. Adjudication of degraded ground water basins should be considered as a tool for implementation of water quality goals to be utilized only if other measures fail.

8. Water supply improvements to reduce influent wastewater salinity made in the interest of total water quality management should be considered for partial eligibility for Clean Water Grants. Increased costs for grant eligibility could be in lieu of costs for wastewater effluent demineralization where such measures are required.

9. Water reclamation and reuse programs for supplementing agricultural irrigation supplies should be given increased emphasis. Grant support should be available for water short areas where such water demand can be demonstrated.

III. REGIONAL WATER QUALITY CONTROL BOARD MANAGEMENT PRINCIPLES

III.A. GENERAL

1. Land use practices should assure protection of beneficial water uses and aquatic environmental values.

2. There shall be no waste discharged into areas which possess unique or uncommon cultural, scenic, aesthetic, historical or scientific values. Such areas will be defined by the Regional Board.
3. Property owners are considered ultimately responsible for all activities and practices that could result in adverse affects on water quality from waste discharges and surface runoff.

III.B. WASTEWATER RECLAMATION

1. Water quality management systems throughout the basin shall provide for eventual wastewater reclamation, but may discharge wastes to the aquatic environment (with appropriate discharge requirements) when wastewater reclamation is precluded by processing costs or lack of demand for reusable water.

2. The number of waste sources and independent treatment facilities shall be minimized and the consolidated systems shall maximize their capacities for wastewater reclamation, assure efficient management of, and meet potential demand for reclaimed water.

Further wastewater reclamation guidance is available in the Implementation Plan, Chapter Four.

III.C. DISCHARGE TO SURFACE WATERS

1. All discharges to the aquatic environment shall be considered temporary unless it is demonstrated that no undesirable change will occur in the natural receiving water quality.

2. The quality of all surface waters of the basin shall be such as to permit unrestricted recreational use.

3. The discharge of pollutants into surface fresh waters shall be discontinued.

III.D. MUNICIPAL AND INDUSTRIAL SEWERING ENTITIES

1. Municipal and industrial sewering entities should implement comprehensive regulations to prohibit the discharge to the sewer system of substances listed below which may be controlled at their source:

   Chlorinated hydrocarbons;

   Toxic substances;

   Harmful substances that may concentrate in food webs;

   Excessive heat ;

   Radioactive substances;

   Grease, oil, and phenolic compounds;

   Mercury or mercury compounds;

   Excessively acidic and basic substances:

   Heavy metals such as lead, copper, zinc, etc.; and

   Other known deleterious substances.

2. Sewering entities should implement comprehensive industrial waste ordinances to control the quantity and quality of organic compounds, suspended and settleable substances, dissolved solids, and all other materials which may cause overloading of the municipal waste treatment facility.

III.E. GROUND WATER

1. Ground water recharge with high quality water shall be encouraged.

2. In all ground water basins known to have an adverse salt balance, total salt content of the discharge shall not exceed that which normally results from domestic use, and control of salinity shall be required by local ordinances which effectively limit municipal and industrial contributions to the sewerage system.

3. Wastewaters percolated into the ground waters shall be of such quality at the point where they enter the ground so as to assure the continued usability of all ground waters of the basin.

III.F. INDIVIDUAL, ALTERNATIVE, AND COMMUNITY SYSTEMS

The Regional Board intends to discourage high density development on septic tank disposal systems and generally will require increased size of parcels with increasing slopes and slower percolation rates. Consideration of development will be based upon the percolation rates and engineering reports supplied. In any questionable situation, engineer-designed systems will be required.

Further information concerning on-site systems can be found in Chapter Four.

III.G. EROSION AND SEDIMENTATION CONTROL

1. General recommendations for erosion control, numbered one through six under "Land Disturbance Activities" in the Implementation Plan, Chapter Four, are considered by the Regional Board to be Best Management Practices (BMP's), as are those BMP's identified in approved areawide Water Quality Management Plans.

2. Local units of government should have the lead role in controlling land use activities that cause erosion and may, as necessary, impose further conditions, restrictions, or limitations on waste disposal and other activities that might degrade the quality of waters of the State.

3. In implementing BMP's through local units of government, or through State and federal agencies for lands under their control, working relationships, priorities, and time schedules will be defined in management agency agreements between the areawide waste treatment planning agency and the local management agency. Agreements will be reviewed and updated annually to reflect recent achievements, new information and new concerns.

4. Regional Board participation in sediment control programs shall include assistance in the establishment of local control programs, participation in the determination of water quality problems, and a cooperative program evaluation with local units of government. Regional Board enforcement authority will be exercised where local volunteer programs fail to correct sediment problems within a reasonable period.

5. Emergency projects undertaken or approved by a public agency and necessary to prevent or mitigate loss of, or damage to, life, health, property, or essential public services from an unexpected occurrence involving a clear and imminent danger are exempt from this chapter providing such exemption is in the public interest.

6. Regulation of sediment discharges from routine annual agricultural operations, such as tilling, grazing, and land grading and from construction of agricultural buildings is waived except where such activity is causing severe erosion and causing, or threatening to cause, a pollution or nuisance.

7. Regulation of discharges from State and federal lands managed by agencies operating in accordance with approved management agency agreements is waived except where such activity is causing, or threatening to cause, a pollution or nuisance.

"Control Actions" and "Actions by Other Authorities" in this chapter and the Implementation Plan, Chapter Four, contain further information regarding erosion and sedimentation control.

IV. DISCHARGE PROHIBITIONS

Due to unique cultural, scenic, aesthetic, historical, scientific, and ecological values of the Central Coastal Basin, and the necessity to protect the public health and the desire to achieve water quality objectives, the Regional Water Quality Control Board has established certain discharge prohibitions.

IV.A. ALL WATERS

Waste discharges shall not contain materials in concentrations which are hazardous to human, plant, animal, or aquatic life.

The discharge of oil or any residual products of petroleum to the waters of the State, except in accordance with waste discharge requirements or other provisions of Division 7 of the California Water Code, is prohibited.

Discharge of elevated temperature wastes into COLD intrastate waters is prohibited where it may cause the natural temperature of the receiving water to exceed limits specified in Chapter Three, Water Quality Objectives.

IV.A.1. TOXIC OR HAZARDOUS POLLUTANTS

Discharge of toxic or hazardous material that violates: 1) the toxicity objective for all waters as designated in the Ocean Plan [See Appendix A-5] and Objectives for All Inland Surface Waters, Enclosed Bays, and Estuaries [See Chapter Three], or 2) Proposition 65 limitations for municipal/domestic water supply waters is prohibited.

Discharge to publicly owned treatment works is prohibited in concentrations that:

1. Exceeds applicable federal pretreatment standards;

2. Endangers safe and continuous operation of wastewater treatment facilities;

3. Endangers public health and safety; and

4. Causes violation of applicable water quality objectives.

IV.B. INLAND WATERS

Wastes discharged to surface waters shall be essentially free of toxic substances, grease, oil, and phenolic compounds.

Waste discharges to the following inland waters are prohibited:

1. All surface freshwater impoundments and their immediate tributaries.

2. All surface waters within the San Lorenzo River, Aptos-Soquel, and San Antonio Creek Subbasins <u>and</u> all water contact recreation areas except where benefits can be realized from direct discharge of reclaimed water.

3. All deadend sloughs receiving little flushing action from land drainage or natural runoff.

4. All coastal surface streams and natural drainageways that flow directly to the ocean within the Santa Cruz Coastal, Monterey Coastal, San Luis Obispo Coastal from the Monterey County line to the northern boundary of San Luis Obispo Creek drainage, and the Santa Barbara Coastal Subbasins <u>except</u> where discharge is associated with an approved wastewater reclamation program.

5. The Santa Maria River downstream from the Highway One bridge.

6. The Santa Ynez River downstream from the salt water barrier.

Domestic Animal Waste Discharge Prohibition:

Discharges containing fecal material from domestic animals to the waters of the State that cause or contribute to exceedance of water quality objectives in the areas listed below are prohibited. Examples of domestic animals include, but are not limited to, horses, cattle, goats, sheep, dogs, cats or any other animal(s) in the care of any person(s).

1. Pajaro River Watershed
2. Soquel Lagoon Watershed
3. Aptos Creek Watershed
4. San Lorenzo River Watershed.

Human Fecal Material Discharge Prohibition:

Discharges containing fecal material from humans to the waters of the State in the areas listed below are prohibited. Exceptions to this prohibition include discharges in accordance with Waste Discharge Requirements or other provisions of the California Water Code, Division 7, as amended:

1. Pajaro River Watershed
2. Soquel Lagoon Watershed
3. Aptos Creek Watershed
4. San Lorenzo River Watershed.

IV.C. WATERS SUBJECT TO TIDAL ACTION

The discharge of any radiological, chemical, or biological warfare agent or high level radioactive waste into the ocean is prohibited.

Waste discharges to the following areas are prohibited.

1. In the northern extreme of Monterey Bay, inshore from an imaginary line extending from Santa Cruz Point (36°-57.0'N, 122°-01.5'W) to the mouth of the Pajaro River (36°-51.0'N, 121°-48.6'W) and in ocean waters within a three (3) mile radius of Point Pinos (36°-38.3'N, 121°-56.0'W), excepting the area described in No. 2 below.

2. In the southern extreme of Monterey Bay, inshore from an imaginary line extending from Point Pinos (36°-38.3'N, 121°-56.0'W) to the mouth of the Salinas River (36°-44.9'N, 121°-48.3'W).

Discharges to the Monterey Bay Prohibition Zone from desalinization units and circulating seawater system discharges may be permitted after each proposal satisfies California Environmental Quality Act requirements and completes the National Pollutant Discharge Elimination System process.

IV.C.1. AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

Discharge of waste is prohibited where it will alter natural water quality conditions in Areas of Special Biological Significance. Areas of Special Biological Significance are:

1. Ano Nuevo Point and Island, San Mateo County, including ocean waters within three (3) nautical miles offshore and defined by extensions of Cascade Creek on the north and the Santa Cruz-San Mateo County line on the south.

2. Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge, Monterey County, including Monterey Bay waters bounded by Point Alones on the east, by Point Pinos on the west, and extending offshore to the 60-foot depth contour (about 0.7 miles).

3. Carmel Bay, Monterey County, including all bay waters enclosed by an imaginary line extending between Pescadero Point and Granite Point.

4. Point Lobos Ecological Reserve, Monterey County, including ocean waters within one-quarter (0.25) mile offshore from Granite Point southerly to the southernmost boundary of Point Lobos Reserve State Park.

5. Julia Pfeiffer Burns Underwater Park, Monterey County, including ocean waters within an area extending about one (1.0) mile offshore and about two and one-half (2.5) miles south of Partington Point.

6. Salmon Creek, Monterey County, including ocean waters within one-thousand (1000) feet or more offshore, bounded on the south by an extension of the Monterey-San Luis Obispo County line, and extending northward about three (3) miles.

7. San Miguel, Santa Rosa, and Santa Cruz Islands, Santa Barbara County, including ocean waters within about one (1) nautical mile offshore.

The discharge of municipal and industrial waste sludge and sludge digester supernatant directly to the ocean, or into a waste stream that discharges to the ocean without further treatment, is prohibited.

The bypassing of untreated waste to the ocean is prohibited.

Excepting vessel washdown waters, disposal of waste matter or untreated waste from vessel to tidal water is prohibited.

The discharge of oil or grease, from other than natural sources, which produces a visible or measurable effect to tidal waters of the basin is prohibited.

New thermal waste discharges to coastal waters, enclosed bays and estuaries having a maximum temperature greater than 4°F above the natural temperature of the receiving water are prohibited.

IV.D. GROUND WATERS

Wastes discharged to ground waters shall be free of toxic substances in excess of accepted drinking water standards; taste, odor, or color producing substances; and nitrogenous compounds in quantities which could result in a ground water nitrate concentration above 45mg/l.

IV.E. OTHER SPECIFIC PROHIBITION SUBJECTS

Other prohibitions exist which pertain to the following topics. These prohibitions can be found under the respective heading in the Implementation Plan.

Mushroom Farms Operation Prohibitions

Individual, Alternative, and Community Sewage Disposal Systems Prohibitions

Land Disturbance Prohibitions

Solid Waste Discharge Prohibitions

Watsonville Slough Watershed Livestock Waste Discharge Prohibition

IV.F. EXCEPTIONS TO BASIN PLAN REQUIREMENTS

The Regional Board may, subsequent to a public hearing, grant exceptions to any provision of this Plan where the Regional Board determines:

1. The exception will not compromise protection of waters for beneficial uses; and

2. The public interest will be served.

Regional Board exceptions will be effective upon State Board approval, unless exceptions involve surface water beneficial use designations or surface water quality objectives (i.e., federally accepted water quality standards). Such water quality standard related exceptions will also require Environmental Protection Agency approval to become effective.

V. CONTROL ACTIONS

Specific actions can be taken to control water quality. These are specified below.

V.A. WASTE DISCHARGE REQUIREMENTS

1. The Regional Water Quality Control Board will implement water quality control plan provisions through establishment or requirements and timetables for compliance with plan actions.

2. Waste discharge requirements will be established for all (operating) solid waste sites and where inactivated sites may contribute to water quality impairment.

3. Waste discharge requirements will be established for all existing oil well fields, mines, or other well fields which threaten water quality.

4. Waste discharge requirements will be established for all irrigation, feedlot, dairy, and poultry operations which are so located as to pose a clear and direct threat to water quality; such operations need not be so large as to require a permit under NPDES.

V.B. STATE CLEAN WATER GRANTS OR LOANS

1. Priorities for State Clean Water Grants or Loans will be ordered by the Regional Water Quality Control Board and provide ever increasing emphasis toward correction of basin water quality problems.
2. Water supply improvements (which encourage cost-effective water quality management) beyond normal source control measures (i.e., water supply quality enhancement by treatment or other means in lieu of effluent demineralization) will be recommended for funding.

V.C. SALT DISCHARGE

1. Emphasize control of brine disposal into public sewer systems by requiring affected dischargers to comply with normal salt increments, to adopt salt source control ordinances, and to conduct wastewater monitoring programs.
2. Minimize degradation of water during transport from points of use; minimize leakage of poor quality water during transport from salt affected areas through salt free lands to salt sinks for disposal.

3. Regulate importation of water into any basin or subbasin and regulate the reuse of waters in upstream portions of subbasins which is of poorer quality than existing or imported supplies. If such import or transport to up-slope areas for reuse is allowed, take suitable steps to mitigate short and long term adverse effects of increased salt load resulting from this recycling.

4. Increase recharge of underground water storage basins (where recharge is possible) using surplus winter or spring runoff waters.

5. Actively support measures designed to protect and to improve quality of waters imported into areas with unfavorable or poor salt balance.

6. Regulate reclamation of new lands which would contribute large quantities of salts or pollutants to water supplies.

7. Where water supplies are limited, restrict use of reclaimed waters to existing irrigated acreage rather than develop new irrigated acreage to utilize the reclaimed water.

V.D. INDIVIDUAL, ALTERNATIVE, AND COMMUNITY SEWAGE DISPOSAL SYSTEMS

Unsewered areas having high density (one acre lots or smaller) should be organized into septic tank management districts and sewerage feasibility studies should be encouraged in potential problem areas. Local implementation should be encouraged by Regional Board action.

V.E. AGENCY COORDINATION

The Regional Water Quality Control Board will initiate coordination with the appropriate Coastal Commission, as well as other State, federal, and local agencies which possess related or overlapping planning responsibilities.

V.F. ANIMAL CONFINEMENT OPERATIONS

The California Code of Regulations, Title 23, Chapter 15, Section 2601 defines a confined animal facility as "any place where cattle, calves, sheep, swine, horses, mules, goats, fowl, or other domestic animals are corralled, penned, tethered, or otherwise enclosed or held and where feeding is by means other than grazing."

1. Animal confinement facilities plus adjacent crop land under the control of the operator shall have the capacity to retain surface drainage from manure storage areas plus any washwater during a 25-year 24-hour storm.

2. Surface drainage, including water from roofed areas, shall be prevented from running through manure storage areas.

3. Animal confinement facilities, including retention ponds shall be protected from overflow to stream channels during 20-year peak stream flows for existing facilities and 100-year peak stream flows for new facilities.

4. Retention ponds shall be lined with or underlain by soils containing at least ten percent clay and not more than ten percent gravel or artificial material of equivalent impermeability.

5. Washwater and surface drainage from manure storage areas shall be contained, applied to crop lands, or discharged to treatment systems subject to approval by the Regional Water Quality Control Board.

6. Animals in confinement shall be prevented from entering any surface waters within the confined area.

7. Lands that have received animal wastes shall be managed to minimize erosion and runoff. Dry manures applied to cultivated crop lands should be incorporated into the soil soon after application.

8. Animal wastes shall be managed to prevent nuisances in manure storage areas.

9. Manure storage areas shall be managed to minimize percolation of water into underlying soils; this may be accomplished by routing drainage to impervious storage areas, land applications, relocation of existing lots and, in the case of new locations, by selecting more impervious soils for manure storage areas.

10. Animal confinement facilities shall have adequate surface drainage to prevent continuous accumulation of surface waters in corrals and feed yards; drainage should be routed to impervious storage areas or applied to land.

11. Application of manures and washwaters to crop lands shall be at rates which are reasonable for crop, soil, climate, special local situations, management system and type of manure.

12. A monitoring program may be required by the Regional Water Quality Control Board as a condition to issuance or waiver of waste discharge requirements.

Further animal confinement information can be found in Chapter Four in the Nonpoint Source Measures section under Agricultural Water and Wastewater Management.

V.G. EROSION AND SEDIMENTATION

1. Erosion from nonpoint pollution sources shall be minimized through implementation of BMP's (identified under "Management Principles" and

described under "Land Disturbance Activities" in Chapter Four's "Nonpoint Source Measures" section.

2. All necessary control measures for minimizing erosion and sedimentation, whether structural or vegetal, shall be properly established prior to November 15 each year.

3. All structural and vegetal measures taken to control erosion and sedimentation shall be properly maintained.

4. A filter strip of appropriate width, and consisting of undisturbed soil and riparian vegetation or its equivalent, shall be maintained, wherever possible, between significant land disturbance activities and watercourses, lakes, bays, estuaries, marshes, and other water bodies. For construction activities, minimum width of the filter strip shall be thirty feet, wherever possible as measured along the ground surface to the highest anticipated water line.

5. Design and maintenance of erosion and sediment control structures, (e.g., debris and settling basins, drainage ditches, culverts, etc.) shall comply with accepted engineering practices.

6. Cover crops shall be established by seeding and/or mulching, or other equally effective measures, for all disturbed areas not otherwise protected from excessive erosion.

7. Land shall be developed in increments of workable size that can be completed during a single construction season. Graded slope length shall not be excessive and erosion and sediment control measures shall be coordinated with the sequence of grading, development, and construction operations.

8. Use of soil sterilants is discouraged and should be minimized.

Further erosion and sedimentation information can be found in other areas of this chapter as well as the Implementation Plan, Chapter Four, under "Land Disturbance Activities."

V.H. ACTIONS BY OTHER AUTHORITIES

V.H.1. FEDERAL AGENCIES

1. Federal agencies directly affected by the facility plans involving consolidation with other communities should comply with applicable provisions of the Basin Plan (e.g., Fort Ord on the Monterey Peninsula is shown as part of municipal wastewater sewerage consolidation); agency policies favoring plan recommendations are encouraged.

2. Federal agencies otherwise affected by plan provisions should signify their compliance or concern with plan recommendations; time at public hearings will be provided for this purpose.

V.H.2. ASSOCIATION OF MONTEREY BAY AREA GOVERNMENTS

The Association of Monterey Bay Area Governments (AMBAG) should coordinate with local agencies and the Regional Board relative to implementation of water quality control plans in that area.

V.H.3. SEPTIC TANK MANAGEMENT AGENCIES

1. County governments should revise septic tank ordinances to conform with basin plan recommendations and State Board guidelines.

2. Formation of septic tank management districts within existing local agencies should be accomplished in areas where directed by Regional Board action.

V.H.4. WATER MANAGEMENT AGENCIES

Conjunctive ground water-surface water management should continue to be encouraged by water management agencies, both in terms of storage and recharge operations and containment and routing of highly mineralized surface waters to prevent recharge. Examples in the Salinas Subbasin include storage of wet weather flows and recharge from a reservoir on Arroyo Seco and containment to prevent recharge of highly mineralized surface waters in streams such as Pancho Rico Creek.

V.H.5. SOLID WASTE MANAGEMENT

Preparation of solid waste management plans by all counties in the basin should be accomplished as required by the Nejedly-Z'berg-Dills Solid Waste Management and Resource Recovery Act of 1972.

V.H.6. AGRICULTURAL MANAGEMENT

Local agricultural representatives and the University of California extension service should maintain liaison with the Regional Water Quality Control Board and the State Board relative to agricultural wastewater management.

V.H.7. OFFSHORE OIL

Water quality in offshore oil lease areas should be monitored by State and federal agencies preferably by arrangements with independent oceanographic institutions.

V.H.8. SALINITY MANAGEMENT

Salt source control measures should be implemented by municipalities having excessive mineral quality in wastewaters discharged to land or inland waters; control of salinity through water supply improvements is recommended.

V.H.9. SEAWATER INTRUSION

Water Management Plans should be prepared and adopted by Monterey County for the Salinas ground water basin and the Pajaro Valley Water Management Agency for the Pajaro ground water basin. These management plans should include immediate actions these agencies can take to help alleviate seawater intrusion as well as measures to stop seawater intrusion from advancing. These agencies should remediate seawater intrusion as a long-term goal.

Local and State agencies having jurisdiction to help control seawater intrusion should assist in implementing seawater intrusion remedies.

V.H.10. EROSION AND SEDIMENTATION CONTROL

1. The federal government should increase its support of erosion and sediment control programs by increasing its technical staffs, increasing cost-share funds, increasing the availability of low-interest loans, and changing its income tax laws to encourage the use of Best Management Practices for erosion and sediment control.

2. The State of California should establish an erosion and sediment control program that includes incentives for the individual - such as cost-sharing, changes in State law that would reduce property taxes for enduring erosion and sediment control practices, and incentives through state income taxes.

3. Resource Conservation Districts within the Central Coast Region should develop management agency agreements with the Regional Board agreeing to work jointly with the Regional Board to integrate soil and water resource programs in the application of Best Management Practices to correct existing erosion and sediment problems and to prevent new problems from occurring.

4. Local units of government should improve land use plans to establish a clear policy, and shall adopt or improve ordinances to include definitive performance standards, for the control of erosion and sedimentation, including consistency with this Basin Plan and Best Management Practices identified under Regional Board "Management Principles."

5. Local units of government developing Local Coastal Programs shall establish a clear policy on erosion and sedimentation and adopt an ordinance consistent with Best Management Practices for their land areas within the Coastal Zone.

6. Resource Conservation Districts, the U.S.D.A. Soil Conservation Service, the California Department of Transportation, and the Extension Service, in conjunction with the cities and counties, should develop and carry out an erosion and sediment control training program for employees who check erosion and sediment control plans and who enforce local ordinances and regulations relating to erosion and sediment control practices.

7. Counties and cities should work with the Regional Board to identify priorities, time schedules, and limitations and to negotiate management agency agreements concerning implementation of Best Management Practices for control of erosion and sedimentation.

8. Review and assessment of erosion and sediment control plans for new land developments in those counties and cities that have signed management agency agreements with the Board will be processed entirely by that county or city.

VI. REGIONAL BOARD POLICIES

Formal specific policies adopted by the Regional Board are presented below according to various categories.

VI.A. SEWERAGE FACILITIES AND SEPTIC TANKS IN URBANIZING AREAS IN THE CENTRAL COAST REGION

Resolution 69-01: Adopting Policy Statement Regarding Sewerage Facilities and Septic Tanks in Urbanizing Areas in the Central Coast Region.

This policy prohibits septic tank or community systems unless particular criteria are satisfied.

VI.B. SEPTIC TANKS

1. Resolution 86-02: Acceptance of Monterey County Board of Supervisor's Ordinance Applying Development Restrictions to the Bay Hills (Bay Farms/Hillcrest) Area.

   This policy accepts Monterey County's moratorium in lieu of a Regional Board prohibition. Further, the policy requested a compliance schedule to eliminate discharge from individual sewage disposal systems and the State Water Resources Control Board is requested to rank this project Class "A" on the Clean Water Grant project priority list.

2. Resolution 87-05: Acceptance of Monterey County Board of Supervisor's Ordinance Applying Development Restrictions to the area within the San Lucas County Water District.

   This policy accepts Monterey County's moratorium in lieu of a Regional Board prohibition. Further, the policy requested a compliance schedule to eliminate discharge from individual sewage disposal systems and the State Water Resources Control Board is requested to rank this project Class "A" on the Clean Water Grant project priority list.

Further information concerning on-site system development restrictions can be found in Chapter Four.

VI.D. AREA OF SPECIAL BIOLOGICAL SIGNIFICANCE (ASBS)

Resolution 76-10: Recommendation to the State Water Resources Control Board Concerning the Designation of Terrace Point in Santa Cruz County as an Area of Special Biological Significance.

This policy recommended the State Water Resources Control Board to not designate Terrace Point as an Area of Special Biological Significance. The State Board concurred with the Regional Board in Resolution 77-21.

Further information concerning ASBS areas can be found in Chapter Two.

VI.E. LEGISLATIVE MATTERS

Resolution 78-04: Supporting Approval of the Clean Water and Water Conservation Bond Law of 1978.

This policy expressed support for Proposition Two and urged California voters to support the proposition.

VI.F. PROHIBITION ZONES

Resolution 79-06: Resolution Regarding Marina County Water District's Petition to Delete the Southern Monterey Bay Discharge Prohibition Zone from the Basin Plan.

This policy considers Marina County Water District challenge to the Southern Monterey Bay prohibition zone. This policy resolves the Southern Monterey Bay prohibition zone is appropriate.

Regional Board adopted prohibition zones for tidal waters can be found under "Waters Subject to Tidal Action" under "Discharge Prohibitions" in this chapter.

VI.G. SAN LORENZO VALLEY

Resolution 87-04: Certification of Santa Cruz County's Wastewater Management Program for the San Lorenzo River Watershed.

This policy certifies Santa Cruz County's Wastewater Management Program for the San Lorenzo Valley is adequate to satisfy the loan condition authorized by Chapter 962 of the 1986 State Statues.

VI.H. HIGHWAY GROOVING RESIDUES

Resolution 89-04: Adopting Policy Regarding Disposal of Highway Grooving Residues.

This policy specifies conditions for highway grooving residue disposal.

VI.I. WAIVER OF WASTE DISCHARGE REQUIREMENTS

Resolution 89-04: Waiver of Regulation of Specific Types of Waste Dischargers.

State law allows Regional Boards to waive waste discharge requirements (WDRs) for a specific discharge or types of discharges where it is not against the public interest (California Water Code Section 13269). These waivers are conditional and may be terminated at any time.

On April 15, 1983, the Regional Board held a public hearing regarding the types and nature of waste discharges considered for waiver. Following this hearing, the Regional Board established certain discharges which waived WDRs. The types of dischargers which may be waived are shown in the appendix.

VI.J. INTERPRETATION OF MINIMUM PARCEL SIZE REQUIREMENTS FOR ON-SITE SEWAGE SYSTEMS

This policy clarifies Regional Board minimum parcel size requirements for on-site systems contained in Chapter Four of this document.

A copy of this policy is shown in the appendix.

VI.K. APPRECIATION FOR DISCHARGER COMPLIANCE

Resolution 93-04: Appreciation for Discharger Compliance.

This policy addresses the manner in which the Regional Board will protect water quality protection and improvement at the most cost effective manner to society. A copy of the policy is shown in the appendix.

CHAPTER 6. MONITORING AND ASSESSMENT

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I. INTRODUCTION

The effectiveness of a water quality control program cannot be judged without the information supplied by a comprehensive and systematic monitoring and assessment program. This chapter describes statewide and regional monitoring and assessment programs designed to provide scientific information on water quality in the Central Coast Region. The Regional Board uses information produced by these programs to satisfy requirements of both the federal Clean Water Act (http://www.swrcb.ca.gov/rwqcb3/) and applicable portions of the state's Porter-Cologne Water Quality Control Act.

Monitoring information is presented for both regulatory and ambient monitoring programs at the State and Regional level. Regulatory monitoring programs address compliance issues related to discharges to waters of the State. Ambient monitoring programs address overall quality of waters of the State, generally without regard to specific dischargers.

II. OBJECTIVES

General objectivesof statewide and regional monitoring and assessment programs are:

1. To measure the achievement of water quality goals and objectives specified in this plan.

2. To measure specific effects of water quality changes on established beneficial uses.

3. To measure background conditions of water quality and long-term trends in water quality.

4. To locate and identify sources of water pollution that pose an acute, cumulative, and/or chronic threat to the environment.

5. To provide information needed to correlate receiving water quality to mass emissions of pollutants by waste dischargers.

6. To provide data for determining waste discharger compliance with permit conditions.

7. To measure waste loads discharged to receiving waters and to identify the limits of their effect, and in water quality limited segments to prepare waste load allocations necessary to achieve water quality control.

8. To provide documentation necessary to support enforcement of permit conditions and waste discharge requirements.

9. To provide data needed to carry on the continuing planning process.

10. To measure the effects of water rights decisions on water quality and to guide the State Board in its responsibility to regulate unappropriated water for the control of quality.

11. To provide a clearinghouse for the collection and dissemination of water quality data gathered by other agencies and private parties cooperating in the program.

12. To prepare reports on water quality conditions as required by federal and State regulations and other users requesting water quality data.

III. QUALITY CONTROL

Federal regulations and State policy require the preparation and implementation of Quality Assurance/Quality Control Plans for most monitoring carried out by the Regional Board's staff or its contractors. Regional Board monitoring activities are usually conducted under the Quality Assurance Program Plan developed for the Surface Water Ambient Monitoring Program (SWAMP).

Sample analysis generally must be conducted by a State-certified laboratory ;the laboratory must have an approved Quality Assurance/Quality Control program and must be certified under the California Department of Health Services (DHS) Accreditation Program. In some instances, DHS certification may not be required, provided the laboratory has appropriate performance based standards.

IV. REGULATORY MONITORING AND ASSESSMENT

IV.A. COMPLIANCE MONITORING

A significant component of the State's regulatory monitoring relates specifically to discharges of pollutants from known sources. All entities holding Regional Board Discharge Orders must conduct regular sampling and analysis of waste released to surface and ground waters. Entities granted a discharge waiver may also be subject to monitoring requirements as a condition of the waiver.

The specific chemical and physical parameters to monitor, types of sampling and analyses (e.g., waste stream sampling, toxicity tests, etc.), frequency, and other specific requirements are determined on a case-by-case basis according to the nature of the discharge and potential environmental effects. Each Order or waiver issued by the Regional Board describes the specific compliance monitoring requirements for that Order or waiver holder.

Monitoring data collected by point source dischargers and nonpoint pollution control programs are used to:

- Determine compliance with and provide documentation to support enforcement of Order or waiver conditions;
- Provide information needed to relate receiving water quality to mass emission of pollutants by dischargers.

Discharger self-monitoring reports, generated as a result of an Order, are collected and reviewed by Regional Board staff for compliance. Any necessary enforcement actions are the responsibility of, and are carried out by, the Regional Board. Self-monitoring reports are normally submitted by the discharger on a

regular basis (monthly, quarterly, or semi-annually) as specified by the Order conditions.

Compliance monitoring includes a control procedure whereby Regional Board personnel periodically visit each discharger on both an announced and unannounced "Facility Inspection" basis. The intent of announced visits is to work with the discharger to review his procedures in order to assure quality control. The intent of the unannounced inspections is to survey the operation, inspect the discharge area, and collect, check, or reference samples. Data from self-monitoring may also be supplemented with information obtained by Regional Board staff through special studies, such as those characterizing the variability of the discharge, pollutant levels in nearby receiving water and biota, and characterization of pollutant loads attributable to urban runoff.

IV.B. COMPLAINT INVESTIGATION

Complaint Monitoring involves investigation of complaints of citizens and public or governmental agencies on the discharge of pollutants or creation of nuisance conditions. It is the responsibility of the Regional Board to address the complaint, including preparation of reports, letters, or other follow-up actions, to document the observed conditions, and to inform the State Board, complainant, and discharger of the observed conditions.

IV.C. AERIAL SURVEILLANCE

Aerial surveillance is used primarily to gather photographic records of discharges, water quality conditions, and conditions at solid waste disposal sites in the Region. Aerial surveillance is particularly effective because of the overall view of a facility that is obtained and because many facilities can be observed in a short period of time.

V. AMBIENT MONITORING AND ASSESSMENT

V.A. STATE MONITORING PROGRAMS

Section 13160 of the Porter-Cologne Water Quality Control Act delegates primary responsibility for coordination and control of water quality in California to the State Board. Section 13163 of the Act states that in conducting this mission, the State Board is to coordinate water quality investigations, recognizing that other State agencies may have primary statutory responsibility for such investigations.Pursuant to these mandates, the State Board has established multiple water quality monitoring programs for California. Other agencies that conduct water-quality monitoring include the California Department of Health Services (DHS), California Department of Water Resources (DWR), California Department of Fish and Game (DFG), California Department of Pesticide Regulation (DPR), California Department of Toxic Substances Control (DTSC), Federal Bureau of Reclamation, the United States Geological Survey (USGS), and the United States Environmental Protection Agency (USEPA).

V.A.1. SURFACE WATER AMBIENT MONITORING PROGRAM

The Porter-Cologne Water Quality Control Act and the federal Clean Water Act (CWA) direct water quality programs to implement efforts intended to protect and restore the integrity of waters of the State. Ambient monitoring is independent of regulatory water quality programs and serves as a measure of the overall quality of water resources and the overall effectiveness of the Regional Board's prevention, regulatory, and remedial actions.

The Surface Water Ambient Monitoring Program (SWAMP) is designed as an ongoing program to

assess the effectiveness of State and Regional Board regulatory water quality programs, to develop a statewide picture of the status and trends in surface water quality, and to develop site-specific information in areas that are known or suspected to have water quality problems. In particular, SWAMP is intended to meet four goals:

1. Identify specific problems preventing the State Board, the Regional Board, and the public from realizing beneficial uses in targeted watersheds.
2. Create an ambient monitoring program that addresses all hydrologic units of the state using consistent and objective monitoring, sampling and analysis methods; consistent data quality and assurance protocols; and centralized data management.
3. Document ambient water quality conditions in potentially clean and polluted areas.
4. Provide data to evaluate the effectiveness of water quality regulatory programs in protecting beneficial uses of waters of the State.

In achieving these goals, each of the State and Regional Board monitoring programs (e.g., State Mussel Watch, Toxic Substances Monitoring) are incorporated into SWAMP to ensure a coordinated approach without duplication. Fiscal Year (FY) 00-01 marked the first year of implementation of the SWAMP Program. The Central Coast Ambient Monitoring Program (CCAMP), which has been underway since 1997, represents the Central Coast Region's participation in the statewide SWAMP Program. More detailed information on the SWAMP program can be found at the State Board website (http://www.swrcb.ca.gov). A summary of the CCAMP program is contained in this chapter.

V.A.2. TOXIC SUBSTANCE MONITORING PROGRAM

The Toxic Substance Monitoring (TSM) Program was initiated in 1976 by the State Board to provide a uniform statewide approach to the detection and evaluation of toxic substances in organisms found in fresh, estuarine, and marine waters of the State. The TSM program uses resident fish and other aquatic organisms (primarily crayfish) to monitor pollutant levels through tissue analysis. Results of tissue analyses reflect exposure to contaminants over extended periods of time and therefore provide a field-based estimate for long-term exposure of people, fish, and other wildlife to pollutants in the food chain. This approach also allows for capture of potentially toxic discharges that occur on an intermittent basis that might otherwise be missed with "grab" sampling of water.

The primary objectives of the TSM program are:

1. To develop statewide baseline data and to demonstrate trends in the occurrence of toxic elements and organic substances in aquatic biota.

2. To assess impacts of accumulated toxicants upon the usability of State waters by man.

3. To assess impacts of accumulated toxicants upon aquatic biota.

4. Where problem concentrations of toxicants are detected, to attempt to identify sources of toxicants and to relate concentrations found in the biota to concentrations found in the water.

TSM reports have been published periodically since 1977. Tissue samples are analyzed for metals, including arsenic, cadmium, chromium, copper, lead, nickel, silver, zinc and mercury. In addition, both invertebrate and fish tissue samples are analyzed for synthetic organic compounds, most of which are pesticides (Table 6-1). Both TSM and State Mussel Watch (SMW) Program publications and data can be found at the State Board website (http://www.swrcb.ca.gov).

V.A.3. STATE MUSSEL WATCH PROGRAM

The State Mussel Watch (SMW) program is a long-term marine water-quality monitoring program initiated in 1977. The SMW program uses resident and transplanted bivalves (e.g., mussels and clams) to monitor pollutant levels at coastal reference stations and selected sites in bays and estuaries to identify or confirm potential toxic substance pollution.

Table 6-1. Synthetic Organic Compounds Analyzed in the Toxic Substances Monitoring and State Mussel Watch Programs

COMPOUND	COMPOUND	COMPOUND
Aldrin	DDMU pp	Nitrofen (TOK)
Benefin	DDT pp	Oxychlordance
BHCα	Dialifor	Parathion, ethyl
BHCβ	Diazinon	Parathion, methyl
BHCγ(lindane)	Dichlofenthion	PCB 1248
BHCδ	Dicofol (Kelthane)	PCB 1254
Carbophenothion	Dieldrin	PCB 1260
CDEC (Vegedex)	Endosulfan I (Thiodan I)	PCNB (Quintozene)
Chlorbenside	Endrin	Perthane
cis-Chlordane	EPN	Phenkapton
trans-Chlordane	Ehtion	Phorate (Thimet)
Chloroneb	Fenitrothion	Ronnel
Chlorpyrifos (Dursban)	Fonofos (Dyfonate)	Strobane
Dacthal	Heptachlor	Tetradifon (Tedion)
DDE op	Heptachlor epoxide	Toxaphene
DDE pp	Hexachlorobenzene (HCB)	2,4-D isopropyl ester
DDD op	Methoxychlor pp '	2,4-D isobutyl ester
DDMS pp	Mirex	2,4-D n-butyl ester

Mussels are used as sentinel organisms for trace metals and synthetic organic compounds in coastal and estuarine waters. Although the mussel populations of bays and estuaries are of a different species than those found in the open coast, their suitability as sentinels for monitoring the presence of toxic pollutants stems from several factors including: (1) their ubiquity along the California coast; (2) their ability to concentrate pollutants above ambient sea water levels and to provide a time-averaged sample; and (3) their non-motile nature which permits a localized measurement of water quality.

The primary goals of the SMW program are as follows:

1. To provide long-term monitoring of selected toxic substances in coastal waters;

2. To provide an important element in a comprehensive water quality monitoring strategy;

3. To identify on a year-to-year basis specific areas where concentrations of toxic materials are higher than naturally occurring background levels.

Tissue samples are analyzed for trace metals including aluminum, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver and zincand for synthetic organic compounds listed in Table 6-1. During the 1977 and 1978 sampling periods, the focus of the SMW program was, for the most part, on open coast monitoring of sites outside the vicinity of known pollutant point sources. Monitoring water quality in the State Board's designated Water Quality Protection Areas (formerly known as Areas of Special Biological Significance), to establish baseline conditions relating to the range of typical conditions in water, sediment and biota, was given prime importance in the early years of the program.
Based on identification of "hot spot" areas during 1977 and 1978, intensive sampling of these areas was implemented in 1979. Such a sampling strategy was intended to confirm previous findings, establish the magnitude of the potential problem and identify pollutant sources. The program has since evolved to include transplanting mussels into selected California bays and estuaries at specific sites to confirm potential toxic substance pollution,e.g., in the vicinity of discharges. In some cases the SMW program deploys freshwater clams or other organisms into fresh water streams and rivers to provide information about toxic substance pollution in watershed systems.

As with the TSM, statewide SMW reports are published periodically, available at the State Board website (http://www.swrcb.ca.gov).

V.A.4. GROUNDWATER AMBIENT MONITORING AND ASSESSMENT

The State Board, pursuant to provisions of the 1999 Budget Act, has developed a statewide Groundwater Ambient Monitoring and Assessment (GAMA) Program, which includes the collaborative efforts of other state and federal agencies also charged with groundwater monitoring responsibilities. The goal of GAMA is to provide information on the quality of California's groundwater and assess relative susceptibility of groundwater resources in California, especially those used as a drinking water supply. The GAMA program has two primary components: the California Aquifer Susceptibility (CAS) Assessment, which addresses public drinking water wells, and the Voluntary Domestic Well Assessment Project which addresses private domestic drinking water wells.

V.A.4.a. CALIFORNIA AQUIFER SUSCEPTIBILITY ASSESSMENT

The State Board, in coordination with the DHS, DWR, and local water districts and purveyors, is implementing the California Aquifer Susceptibility (CAS) Assessment to determine water quality and relative susceptibility of groundwater that serves as a source for public water supplies to possible contaminants. CAS employs a groundwater age dating technique (tritium-helium analysis) and low-level detection (microgram/liter range) of volatile organic compounds (VOCs) to assess aquifer susceptibility. A fundamental premise of the CAS assessment is that groundwater age can be used as a guide for assessing aquifer susceptibility, i.e., young groundwater age implies relatively rapid recharge of surface water to the aquifer, and therefore potentially rapid migration of surface contaminants to the aquifer. Low-level VOC detection is used to corroborate age-dating data and to also identify public supply wells that are already impacted by contaminants, but are still below action levels. This provides an "early warning system" for potentially significant VOC contamination.

In coordination with the USGS and Lawrence Livermore National Laboratory (LLNL), the CAS

assessment is designed to sample the approximately 16,000 public supply wells statewide, beginning with more urbanized areas. Sampling began in September 2000 and will continue for the next several years over the entire state, depending on the availability of funding. General constituents sampled by the USGS and LLNL for low-level VOC analysis are available at the State Board website (http://www.swrcb.ca.gov). Additional constituents may be chosen based upon specific site or land-use conditions.

Groundwater quality, age-dating, and hydrogeologic data collected as part of the CAS assessment are managed utilizing the Geographical and Environmental Information Management System (GEIMS)/GeoTracker system, an internet-accessible geographic information system (GIS) that provides access to water quality data. GeoTracker can be found at http://geotracker.swrcb.ca.gov/.

V.A.4.b. VOLUNTARY DOMESTIC WELL ASSESSMENT

The Voluntary Domestic Well Assessment Program consists of sampling domestic wells for various constituents that may be found in domestic well water, including nitrates, total and fecal coliform bacteria, Methyl tert-Butyl Ether (MTBE), and various minerals. This information is provided to domestic well owners and groundwater agencies. The Voluntary Domestic Well Assessment Program focuses on specific areas, as resources permit and are chosen based upon existing knowledge of water quality and land use, in coordination with local environmental agencies. The State Board incurs the costs of sampling and analysis.

V.A.5. GROUNDWATER QUALITY MONITORING ACT OF 2001

Assembly Bill 599 (AB 599), effective January 1, 2002, established the Groundwater Quality Monitoring Act of 2001 (sections 10780-10782.3 of the California Water Code). The Act requires the State Board to integrate existing monitoring programs with new program elements, as necessary, for the purpose of establishing a comprehensive groundwater monitoring program capable of assessing each groundwater basin in the state, either through direct or other statistically reliable sampling approaches. A second fundamental component of this Act is to increase the availability of water quality data and information to the public.

AB 599 requires the State Board to create an Interagency Task Force (ITF) to identify actions necessary to establish a groundwater-quality monitoring program, and to identify measures that would increase coordination among agencies that collect groundwater quality information. In addition, the State Board is also to convene a Public Advisory Committee (PAC) to the ITF. The AB 599 PAC is to consist of representatives from federal agencies, public water systems, environmental organizations, local water agencies, agriculture, groundwater management entities, and the business community. In coordination with the ITF and the PAC, the State Board must submit to the Governor and the Legislature, on or before March 1, 2003, a report that includes a description of a comprehensive groundwater-quality monitoring program for the State.

V.B. REGIONAL MONITORING PROGRAMS

V.B.1 CENTRAL COAST AMBIENT MONITORING PROGRAM

In 1998, the Central Coast Ambient Monitoring Program (CCAMP) was formally established by the Regional Board to provide integrated and systematic information on surface water quality in the Region, in order to evaluate the effectiveness of Regional Board efforts to meet Basin Plan water quality objectives and protect beneficial uses. CCAMP's general program objectives are to:

1) Acquire and evaluate existing monitoring data and other information, from agencies, volunteer programs, and other sources.
2) Collect ambient monitoring data for the Region's watersheds, coastal confluences, and nearshore areas.
3) Conduct periodic detailed assessments of the Region's watersheds, groundwater basins, coastal confluences, and nearshore areas.
4) Utilize monitoring data and other information to maintain and update the Region's Water Quality Assessments and list of impaired waterbodies and beneficial uses.
5) Provide information presentations through the use of geographic information systems

technology and other forms of graphic visualization.

6) Provide data and information dissemination services through the Internet.
7) Conduct periodic assessments of other programs' activities to eliminate gaps, overlaps, and duplications of effort, and utilize external information whenever possible as a component of the Ambient Monitoring Program.
8) Work with other monitoring programs, including volunteer programs, to develop consistent monitoring protocols and methods, quality control standards, data management procedures, and to encourage efforts consistent with regionwide monitoring goals.
9) Coordinate data management activities with other programs to maximize accessibility and usability of data.

The CCAMP monitoring strategy calls for dividing the Region into five watershed rotation areas and conducting synoptic, tributary-based sampling each year in one of the areas. Over a five-year period, each of the major Hydrologic Units in the Region are monitored and evaluated. In addition to the tributary-based site selection approach, additional monitoring sites are established in each rotation area to provide focused attention on watersheds and waterbodies known to have water quality impairments or other issues of interest.

The CCAMP strategy for establishing and maintaining permanent long-term monitoring sites provides a framework for trend analysis and detection of emergent water quality problems. CCAMP uses a variety of monitoring approaches to characterize water quality conditions and trends in coastal watersheds, including:

- Rapid bioassessment using benthic invertebrates
- Conventional water quality analysis
- Analysis of tissue, water, and sediment for organic chemicals and metals
- Toxicity evaluations
- Habitat assessments

To develop a broad picture of the overall health of waters in the Region, a similar baseline monitoring study design is applied in each rotation area. This provides for compatibility across the Region and allows for prioritization of problems across a relatively large spatial scale. The CCAMP strategy also allows for incorporation of watershed-specific knowledge so that questions which are narrower in focus can be addressed. For example, in watersheds where TMDL assessments are being conducted, additional information is collected as necessary to support development of the analysis. Special studies are undertaken as funding and staffing permits to further focus monitoring on questions of interest specific to individual watersheds.

Coastal Confluences monitoring is another CCAMP program component that focuses on monitoring "integrator sites" at the lower ends of rivers and creeks at their outflow to the ocean. Sampling at these sites is conducted continuously, rather than in a five-year rotation. These sites aid in long-term trend detection, regional priority setting, and understanding inputs to the nearshore environment.

CCAMP nearshore monitoring activities are varied. In the Monterey Bay area, CCAMP has worked with ocean dischargers to redesign and combine receiving water monitoring programs to form the Central Coast Long-term Environmental Assessment Network (CCLEAN). This program characterizes loading of organic pollutants, nutrients and pathogen indicators from discharges and river mouths to the ocean. It also documents associated nearshore conditions, including chemical concentrations in mussel tissue, and nearshore nutrient and toxic phytoplankton concentrations. The CCAMP program directs funding and other support to other marine monitoring activities, including sand crab, mussel, and sea otter tissue analysis for organic chemicals, polynuclear aromatic hydrocarbons, metals, toxic phytoplankton and specific pathogens. CCAMP staff are also working with the local research community to expand the network of instrumented moorings in nearshore areas, with particular focus on nitrate, chlorophyll, and toxic phytoplankton.

More information on the CCAMP program can be found at http://www.swrcb.ca.gov/rwqcb3/. The CCAMP program is conducted in coordination with the TSM and SMW monitoring programs, and satisfies Regional Board requirements for participation in the statewide SWAMP program.

V.C. ASSESSMENTS

V.C.1. STATE WATER QUALITY INVENTORY (305(b)) REPORT

Pursuant to Section 305(b) of the Federal Clean Water Act (PL 92-500), the State Board is required to submit a report on the status of the State's water quality to the USEPA at least every two years. The CWA establishes a process for States to use to

develop information on the quality of their water resources (see USEPA 305(b) reporting guidelines). Specific requirements for this process are also found in Sections 106(e), 204(a), 303(d), and 314(a) of the CWA. Section 305(b) of the CWA specifies that each state must develop a program to monitor the quality of its surface waters and prepare a report describing the status of its water quality; Section 106(e) requests, but does not require, that each state also include the status of ground waters of the state in the report.

The 305(b) process is the principal means by which the USEPA, Congress, and the public evaluate: 1) whether U.S. waters meet water quality standards; 2) progress made in maintaining and restoring water quality; and 3) the extent of remaining problems. Water quality assessment information from California's nine Regional Boards is compiled and presented in conformance with USEPAs 305(b) reporting guidelines through tabulation of the general water quality of waters of the State during the preceding years, including a summary of current designated use support, individual beneficial use support, major causes and sources impacting designated beneficial uses, and associated public health concerns. The Report also contains a brief description of water pollution control policies and programs designed to manage water quality.

Assessment information used for compiling and reporting the 305(b) report is contained in the State's Geospatial Waterbody System (GeoWBS) database, structured for the purpose of producing the 305(b) Report.

V.C.2. STATE WATER QUALITY ASSESSMENT REPORT

The Water Quality Assessment (WQA) report is a biennial compilation of water quality information similar to the biennial Water Quality Inventory (305(b)) report; however, the WQA report contains specific information for individual water bodies of the region rather than generalized summaries for water-body types of the region. Specifically, the WQA categorizes the water quality of each water body by reporting the degree to which beneficial uses are supported (see Basin Plan Chapter 2 for beneficial uses). The levels of beneficial use support are described as: fully supporting, fully supporting but threatened, partially supporting, not supporting, and not assessed. In addition to a description of the level of beneficial use support for each water body, the WQA contains narrative assessment (comments) for selected water bodies of the Region and identifies water bodies included on the Federal 303(d) "list" (numbers refer to sections of the Clean Water Act). The 303(d) list is a list of impaired waters where objectives or goals of the Clean Water Act are not attainable through standard regulatory controls. States are required to prioritize these water bodies for Total Maximum Daily Load (TMDL) development.

As with the 305(b) report, the information used by Regional Board staff in compiling and revising the WQA includes the type of monitoring data discussed in this chapter, records of past Regional Board enforcement actions, professional judgment of Regional Board scientists and engineers, and public comment. WQA information is stored in the GeoWBS database system,

V.C.3. CLEAN WATER ACT SECTION 303(d) LIST OF IMPAIRED WATERS

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that do not meet water quality objectives and are not supporting their beneficial uses. Each state must submit an updated list, called the 303(d) list, to the USEPA every two years. In addition to identifying the waterbodies that are not supporting beneficial uses, the list also identifies the pollutant or stressor causing impairment, and establishes a schedule for developing a control plan to address the impairment.

To develop the list of impaired waters, Regional Board staff relies on data and information collected in the Central Coast Ambient Monitoring Program and other State monitoring programs, along with data and information available from local government or citizen organizations. Staff consider the quality, quantity, timing, and location of data and information for each specified waterbody and the pollutant or stressor potentially causing impairment in that waterbody. Typically, staff compares the levels of the pollutant or stressor to established legal water quality limits (e.g., water quality objectives or other criteria indicating acceptable water quality conditions).

If a waterbody is found to be impaired for a particular pollutant or stressor, it is placed on the list. Once a waterbody and associated stressor pollutant are placed on the list, specific and focused monitoring and assessment efforts are conducted to more fully characterize the nature of the impairment, including identification of the pollutant source(s), and to develop solutions to address the impairment.

V.C.4. CENTRAL COAST AMBIENT MONITORING PROGRAM ASSESSMENTS

Water quality data collected in the CCAMP program is compiled and analyzed to produce watershed assessment reports for the Region. Reports are generated for both surface waters and groundwaters in each watershed, following the CCAMP 5-year rotation monitoring schedule discussed above.

V.C.4.a. Surface water assessments

Surface water assessments are developed using data collected through the CCAMP program and other available information sources, including water quality data from the California Department of Health Services (DHS), United States Geological Survey (USGS), Department of Fish and Game (DFG), Department of Pesticide Regulation (DPR), Toxic Substance Monitoring (TSM) program, National Pollutant Discharge Elimination System (NPDES) discharge data, county data, city data, relevant water quality reports, and any other available literature. Water quality data is also combined with hydrogeomorphic data, land use data, etc., to develop watershed scale assessments, which are, in turn, used to update the 305(b) report and support TMDL development.

V.C.4.b. Groundwater assessments

CCAMP does not actively collect groundwater data, but uses existing sources of data and other available water quality information to develop assessments of groundwater conditions. Data and other information are compiled from the DHS, USGS, California Department of Water Resources (DWR), DPR, and city or county information sources.

Data for both surface and groundwater assessments are evaluated for pollutants of concern, water quality standards exceedances, pollutant levels that warrant attention, beneficial use impairment, spatial and temporal trends, data gaps, and other pertinent information. General evaluations of relationships between surface water and groundwater pollutants are also included in the assessments. Assessment information is then used to develop recommendations for action, to assess future research and monitoring needs, to update the 305(b) report and support TMDL development, and to support permit review activities.

Watershed assessment reports and associated water quality data are available at the CCAMP website (see http://www.swrcb.ca.gov/rwqcb3/ and click on CCAMP).

V.D. OTHER MONITORING AND ASSESSMENT ACTIVITIES

Nonpoint source investigations are conducted to (a) identify the location and nature of sources of nonpoint pollutants; (b) develop information on the quantity, strength, character, and variability of nonpoint source pollutants; (c) evaluate impacts on receiving water quality and biota; (d) provide information useful in management of nonpoint source pollution; and (e) monitor results of any control plan. Investigations are typically undertaken through local agency and watershed group efforts, funded by Federal Clean Water Act grants and other sources.

Special studies and intensive monitoring surveys are conducted to obtain detailed information about a specific water quality problem which, in turn, can be used to evaluate violations of receiving water standards.These studies usually involve localized, intermittent sampling at a higher than normal frequency. These surveys are specially designed to evaluate problems in impaired waterbodies, Water Quality Protection Areas (formerly known as Areas of Special Biological Significance), or hydrologic units requiring sampling in addition to routine monitoring programs. Results from these special studies may be used for addressing impairments identified on the 303(d) List, including Total Maximum Daily Load development, Water Quality Assessment and 305(b) Report updates, and other waterbody assessment activities.

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LAHONTAN REGION (6)
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COLORADO RIVER BASIN REGION (7)
www.waterboards.ca.gov/coloradoriver
73-720 Fred Waring Dr., Suite 100
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SANTA ANA REGION (8)
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SAN DIEGO REGION (9)
www.waterboards.ca.gov/sandiego
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