523 - Gold Ridge Resource Conservation District, Coastal Watersheds Enhancement Project

Gold Ridge Resource Conservation District Technical and Scientific Documentation Table		
Technical Document Name	**Technical Document Description**	**Relevant page #**
Streamline Engineering. Dutch Bill Creek Instream Habitat Enhancement Plans. 2011.	Plans which demonstrate the placement of woody debris in Dutch Bill Creek, near Camp Meeker.	1-7
Prunuske Chatham, Inc. Westminster Woods Water Tank Project. 2012.	Plans for the Irrigation Water Tank Storage project.	all
Supporting Documents provided digitally via the BMS upload and by CD		
Gold Ridge Resource Conservation District. The Salmon Creek Watershed Assessment and Restoration Plan. 31 March 2007.	Through a cooperative effort between several agencies, the goal of this project has been to promote the implementation of needed NPS pollution controls and to assist landowners with best management practices (BMPs) that will restore water quality. The main goal of this project is to improve and protect water quality by helping landowners achieve Tier 1 voluntary compliance with current and future NPS regulations.	2, 15-16, 22-23, 32-63
California Department of Fish and Game (CDFG). Recovery Strategy for California Coho Salmon. Report to the California Fish and Game Commission. Species Recovery Strategy 2004-1. 2004.	The Biological Review Team agreed in 2004 that natural populations of coho salmon in the CCC ESU are in danger of extinction. This determination was based on the following factors: 1) substantially low abundance of coho salmon from historical levels (e.g., more than 50% of coho streams no longer have spawning runs), 2) long-term trends clearly downward, 3) degraded habitats, 4) threats to genetic integrity due to hatchery plantings, and 5) recent droughts and change in ocean productivity. It is believed a high potential for recovery is possible for CCC coho salmon because of the likelihood that freshwater impacts can be substantially controlled or reduced through habitat protection, implementation of best management practices, and focused restoration.	159, 241-242, 331-332
California Department of Fish and Game (CDFG). 2006a. California Department of Fish and Game Stream Inventory Report, Green Valley Creek. Report Revised April 14, 2006, Report Completed 2000, Assessment Completed 1994.	The October 1991 stream survey indicated there was good riparian habitat providing sufficient canopy for shading the stream, although the substrate quality had a high percent of fines, presumably due to conversion of the watershed to agriculture. A major problem noted was the unusually low summer flow, which was mostly subsurface due to high sediment.	4
California Department of Fish and Game (CDFG). 2006b. California Department of Fish and Game Stream Inventory Report, Purrington Creek. Report Revised April 14, 2006, Report Completed 2000, Assessment Completed 1994.	At the time of the survey Purrington Creek was estimated to support runs of coho salmon and steelhead, and provide good nursery habitat with year-round flow, though the small quantity of spawning gravel available appeared to be a limiting factor to fish production.	2
Edwards, C. and Cluer, B. Data Report:	The use of water in the Russian River basin peaks during	1, 13, 24-

Stream Flow Monitoring in Tributaries to the Russian River (Sonoma and Southern Mendocino Counties) 2010 and 2011, NOAA Fisheries Habitat Conservation Division Southwest Region. 2011.	spring when the highest demand for agricultural water is for frost protection of sensitive crops during cold weather episodes that generally occur from March to May. This time of year is when juvenile salmonids are particularly vulnerable as they emerge from gravel redds, adapt to riverine habitat and migrate to suitable summer rearing locales.	25, 39-41,
National Marine Fisheries Service (NMFS). Public Recovery Plan for Central California Coast coho salmon (Oncorhynchus kisutch) Evolutionarily Significant Unit. Santa Rosa (CA): National Marine Fisheries Service, Southwest Region. 2010.	In the freshwater environment coho salmon require: (1) clean gravels for successful spawning and incubation; (2) adequate quantities of cool and well oxygenated water with complex deep pools for juvenile summer rearing; and (3) side channels and alcoves and/or sufficient quantities of large woody debris for over - wintering habitat. Human-made threats include habitat alterations such as water diversion, road building and maintenance, timber harvest, urbanization, flood control structures and practices and climate change.	5
Solazzi, M.F., Nickelson, T.E., Johnson, S.L., and Rodgers, J.D. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences. 57: 906–914. 2000.	Off-channel, high flow refugia will become increasingly vital to salmonid over-winter success and survival. In addition to addressing the barrier of high flow velocities, this project would provide swampy off-channel habitat that coho juveniles have been shown to favor.	6-9
Prunuske Chatham, Inc. Towards a Healthy Wildland Watershed: Willow Creek Watershed Management Plan. March 2005.	To accomplish the vision of viable salmonid populations in Willow Creek, fish passage barriers will be removed, in-stream and riparian habitat enhancement (large woody debris, pools, riffles, food sources) will occur, and sedimentation issues will be addressed. Long-term adaptive management actions may include the CDFG brood stock program. A comprehensive, integrative, and cooperative watershed approach will be taken to address erosion and sedimentation. Evaluation of potential delivery of sediment from both the County road and legacy logging roads in the upper watershed, as well as a partial skid trail inventory, have been completed. The next step will be to identify additional erosion sites, particularly forest and grassland gullies.	21, 49-62, 69-71
Department of Fish and Game. Stream Inventory Report – Dutch Bill Creek. 2000.	In general, Reaches 3 – 7 of Dutch Bill Creek are good for salmon and steelhead habitat. Some deep, sheltered sections of the stream occur in the mid and upper reaches which may be used as rearing habitat. However, in the lower Reaches (1 and the lower portion of 2) pool shelter and the frequency are lacking and portions are dry, limiting successful spawning and rearing.	20-21
DFG. California Salmonid Stream Habitat Restoration Manual – 4th Edition - Part X and XI. 2010.	Part X, Upslope Erosion Inventory and Sediment Control Guidance, describes the California Department of Fish and Game (DFG) methodology for the identification of upslope and stream bank erosion, and techniques for the implementation of cost-effective erosion control treatments in salmonid watersheds.	Entirety

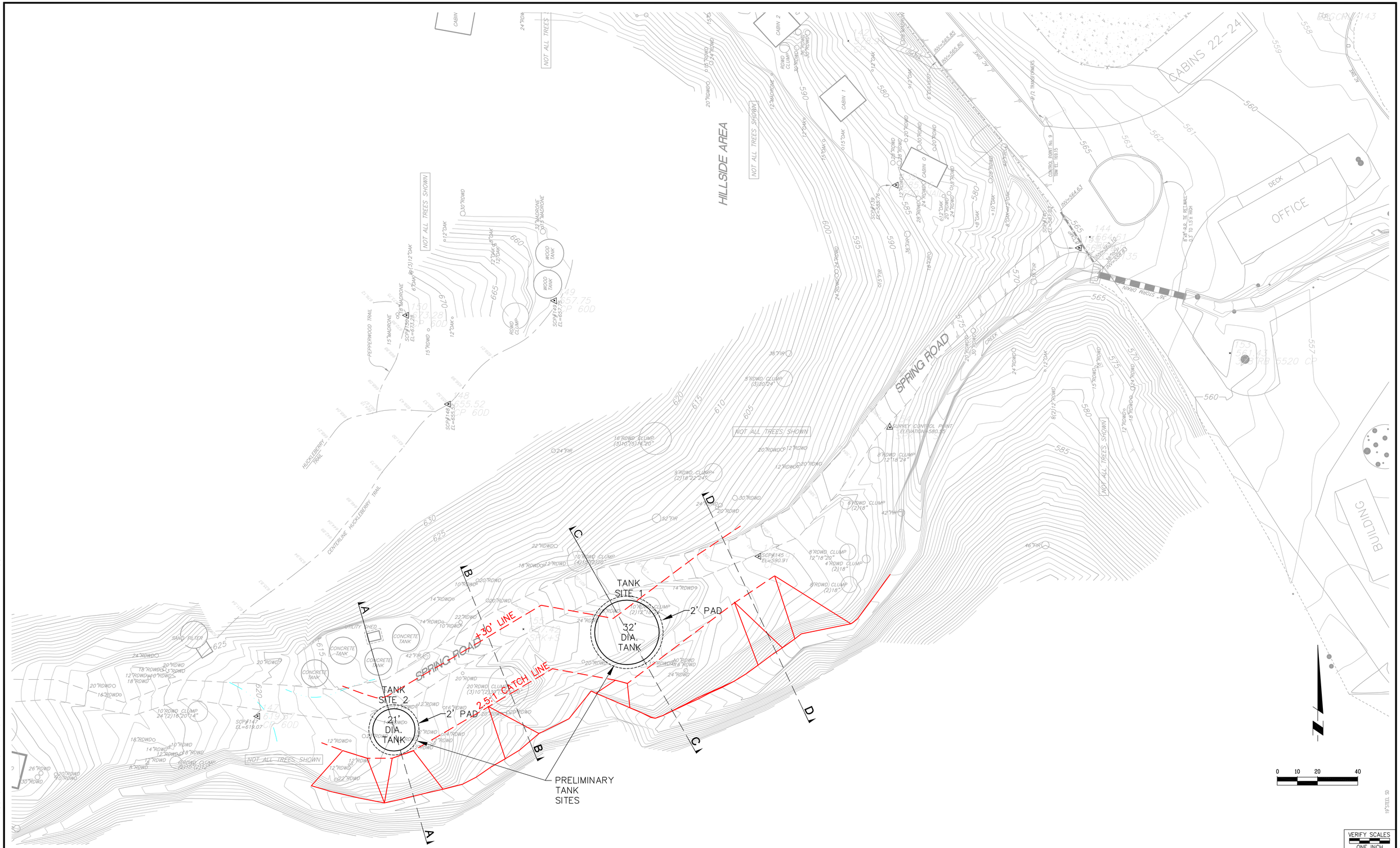
	Large flood events may create the need for erosion control work in the riparian zone to prevent excess siltation into the stream or loss of land. Whenever possible, a vegetative method for reducing erosion such as bioengineering is preferable to a structural approach such as riprap.	14-15
NFWF. Business Plan for the Russian River Coho. 24 March 2009.	Central California Coast (CCC) coho salmon (Oncorhynchus kisutch) are on the brink of extinction. Although their range once stretched inland along more than 250 miles of California's coast, only a few watersheds now support more than remnant populations. The decline of CCC coho salmon has been especially rapid in recent decades, resulting in their listing as endangered under both the State of California and federal Endangered Species Acts. Coho salmon and steelhead trout are similarly addressed in the Highly Migratory Species Fisheries Management Plan.	4, 10-12, 27-28
Steiner Environmental Consulting. A History of the Salmonid Decline in the Russian River. Sonoma County Water Agency / California State Coastal Conservancy / Steiner Consulting, Potter Valley, California. 86 pp. 1996.	This report gathers together the best available information to provide the historical and current status of chinook salmon, coho salmon, pink salmon, and steelhead in the Russian River basin. The last 150 years of human activities have transformed the Russian River basin into a watershed heavily altered by agriculture and urban development. Flows in the main river channel are heavily regulated. The result is a river system with significantly compromised biological functions. The anthropogenic factors contributing to the decline of salmonids are discussed.	5-10, 15, 19-27, 35-40, 47-51, 79-82
University of California Cooperative Extension, Sonoma County. Qualitative Implementation and Effectiveness Monitoring of Fisheries Habitat: A Field Evaluation of Protocols. March 2006.	This body of work presents an opportunity to learn about the intended and unintended outcomes of individual restoration projects as feedback to policy decisions regarding implementation of ecological restoration programs.	7-27
University of California Cooperative Extension, Sonoma County. Quantitative Effectiveness Monitoring of Bank Stabilization and Riparian Vegetation Resotoration: A Field Evaluation of Protocols. March 2007.	Over the past two decades, State and Federal grant programs have funded numerous projects to improve stream habitat, reduce delivery of sediment and other water quality contaminants, and provide stewardship education to public and private land managers in an effort to conserve and enhance habitat functions and maintain or recover species that are dependent upon those functions.	Entirety
University of California Cooperative Extension, Sonoma County. Sediment Delivery Inventory and Monitoring: A Method for Water Quality Management in Rangeland Watersheds. #8014. 2000.	Protecting the beneficial uses of water has become a principal goal of resource management, requiring landowners to adapt their management to comply with water quality regulations.	Entirety
Harris, R.R., C.M. Olson, S.D. Kocher, J.M. Gerstein, W. Stockard and W.E. Weaver. Procedures for Monitoring the Implementation and Effectiveness of Fisheries Habitat Restoration Projects. Center for Forestry, University of	The procedures outlined here recommend qualitative implementation monitoring of all restoration projects. Qualitative effectiveness monitoring would be performed on 10 percent of all projects properly implemented every year. Qualitative monitoring of projects every year constitutes a methodology for	8-24

California, Berkeley. 24 pp. 2005.	assessing practices and would provide a basis for reporting on the overall performance of the FRGP. Quantitative monitoring of individual projects, groups of projects, and smaller watersheds would provide a more rigorous basis for judging the effectiveness of fisheries habitat restoration.	
Smith, R. D. Russian River Watershed Management Plan: Synthesis Report for Baseline Watershed Assessment. U.S. Army Engineer Research and Development Center - Environmental Laboratory. Vicksburg, MS. August 2008.	The Baseline Watershed Assessment task had two primary objectives. The first objective was to collect geospatial data and other information related to the physical, chemical, and biological characteristics of the Russian River watershed, and then organize it in a format that allowed it to be stored, accessed, sorted, cross-referenced, updated, analyzed, and otherwise used efficiently throughout WAMP development. The second objective of the Baseline Watershed Assessment task was to use the geospatial data and other information to evaluate, compare, and rank discrete areas in the Russian River watershed in terms of assessment criteria.	Entirety
Commins, M. L., J. C. Roth, M. H. Fawcett and D. W. Smith. Estero Americano and Estero de San Antonio Monitoring Program, 1988-1989 Results. Santa Rosa Subregional Water Reclamation System. Technical Memo E8. 1990.	Aquatic habitat in the Americano Creek and Stemple Creek watersheds has been studied since February 1988, to evaluate the appropriateness and conditions for reclaimed water reuse for habitat enhancement. This memorandum summarizes the field monitoring data and evaluates possible effects of reclaimed water releases on aquatic organisms."	11-16, 28-35
Gold Ridge Resource Conservation District (GRRCD). The Estero Americano Watershed Management Plan. Version 1, February 2007.	The purpose of this watershed management plan is to characterize and assess the ecological processes and conditions of the Estero Americano Watershed, and to provide economically viable and agreed upon recommendations for improving water quality and the natural resource base through conservation-oriented land management practices.	9-106
Heathwaite, L., A. Sharpley and W. Gburek. A Conceptual Approach for Integrating Phosphorus and Nitrogen Management at Watershed Scales. Journal of Environmental Quality 29: 158-166. 2000.	Since the late 1960s, point-sources of water pollution have been reduced due to their ease of identification and treatment. As water quality problems remain and further point-source measures become less cost-effective, attention is directed toward reducing agricultural nonpoint-sources of P and N.	1-8
Madrone Associates. The Natural Resources of Esteros Americano and de San Antonio. Prepared for California Department of Fish and Game, Coastal Wetlands Series #20. 1977.	Two of California's most interesting coastal wetlands usually go unnoticed by the general public because there is no access from main roads. They lie within the rolling hills of coastal Marin and Sonoma counties and contain marine, freshwater and brackish water habitats in a setting of upland, terrestrial habitats that make them unique among coastal wetlands.	10-17, 28-48, 69-81
Prunuske Chatham, Inc. Stemple Creek/Estero de San Antonio Watershed Enhancement Plan, July 1994. Prepared for Marin County Resource Conservation District and Southern Sonoma Resource Conservation District. 1994.	The Enhancement Plan attempts to pull together the concerns identified and the resources available to address them into an integrated plan of action. The appendices contain five technical reports on the biology, vegetation, erosion and sedimentation, water resources and the hydrology of the Estero. Enhancement	10-26, 47-70

	Recommendations: 1. Encourage the local community to take the lead in Developing and implementing enhancement projects. 2. Assist agricultural producers with practices that promote the conservation and enhancement of natural resources. 3. Reduce pollutants entering Stemple Creek and the Estero. 4. Reduce soil erosion. 5. Encourage environmentally-sound management of rangeland. 6. Conserve and enhance existing natural habitats. 7. Restore the riparian corridor. 8. Develop a long-term Monitoring program. 9. Support agriculture as the major land use in the watershed. 10. Request additional investigation by the Santa Rosa Subregional Water Reclamation System on the potential impacts of the proposed West County Alternative on agriculture and natural resources.	
North Coast Regional Water Quality Control Board (NCRWQCB). Work Plan to Control Excess Sediment. 2008.	The Staff Work Plan to Control Excess Sediment in Sediment-Impaired Watersheds (Work Plan) describes the actions and tasks staff of the North Coast Regional Water Quality Control Board (Regional Water Board) are currently taking or intend to take over the next ten years, as resources allow, to control human-caused excess sediment in the sediment-impaired water bodies of the North Coast Region. The Work Plan is a staff-level planning document that will help prioritize work associated with excess sediment control. The Work Plan was developed by staff to fulfill the Regional Water Board's direction under the Total Maximum Daily Load (TMDL) Implementation Policy Statement for Sediment Impaired Receiving Waters in the North Coast Region (Resolution No. R1-2004-0087).	109-115, 202-207
University of California Cooperative Extension. Habitat conditions, stream flow, temperature, and monthly survival of juvenile coho stocked into two stream reaches in the Mill Creek watershed during the summer dry season, 2009. 2009	To evaluate the effects of changes in flow management that result from Partnership activities, the Partnership's long-term goal is to monitor juvenile coho salmon survival in treatment (flow-impaired) and reference (non-flow impaired) reaches in each of the five priority creeks sampled before and after changes in flow management. In both reference and treatment reaches, estimates of monthly survival during the dry season will be compared with measurements of flow, temperature, and habitat condition. Data will be used to document improvements in flow and survival that result from project implementation in flow impaired reaches.	6-19
Pacific Watershed Associates (PWA). 2008 Green Valley Creek Watershed Assessment and Erosion Prevention Planning Project Sonoma County, California. PWA Report No. 08073301. 2008.	The Green Valley Creek Watershed Assessment and Erosion Prevention Planning Project (GVCWA) area is located in western Sonoma County near the communities of Sebastopol, Graton, and Forestville, California. The project area encompasses 13 private landholdings in the upper and lower Green Valley Creek watersheds, and along the tributary streams of Atascadero Creek and Purrington Creek.	6-24
PWA. 2012 Annual Report, CDFG Grant #P1030426, Green Valley Creek Roads	Road log from Phase II of CDFG Grant #P1030426, Green Valley Creek Roads Implementation Project.	1-16

Implementation Project, Phase II – Appendix A: As-built Road Log. 2012.		
PWA. Handbook for forest and ranch roads. Prepared for the Mendocino County Resource Conservation District in cooperation with the California Dept. of Forestry and the U.S. Soil Conservation Service. Mendocino Resource Conservation District, Ukiah, California. 163 pages. 1994.	Roads need not threaten the biological productivity and water quality of streams in a watershed if they are properly located and constructed. Poor road building and maintenance practices can cause excess runoff and erosion, leading to sedimentation in downstream areas. Sedimentation can pollute water supplies, increase flooding potential, accelerate stream bank erosion and trigger landsliding. Salmonid eggs laid in stream gravels can become buried and suffocate, fish habitat can be lost, and other aquatic life may be threatened or killed.	
Weaver, W. and D. Hagans. Storm-Proofing Forest Roads. Proceedings of the International Mountain Logging and 10th Pacific Northwest Skyline Symposium, OSU Dept. of Forest Engineering and International Union of Forestry Research Organizations, Corvallis, OR. 1999.	Erosion and mass wasting associated with forest roads systems are a common and important accelerated sediment source in many mountainous watersheds.	1-14
DFG. Fish Bulletin 180: California Coastal Salmonid Population Monitoring: Strategy, Design, and Methods. 2011.	This California Coastal Salmonid Monitoring Plan (CMP) has been developed to meet these monitoring needs, describing the overall strategy, design, and methods used in monitoring salmonid populations. Implementation.	9-65
Prunuske Chatham, Inc. Memo: Westminster Woods Water Savings Measures. 2012.	As part of the Westminster Woods Water Storage Project Feasibility Analysis, Prunuske Chatham, Inc. (PCI) has evaluated several options to reduce the irrigation needs of Westminster Woods. The water saving measures chosen for implementation will determine the winter storage volume required to eliminate the withdrawal of irrigation water from Dutch Bill Creek during low-flow periods.	1-5
USDA Forest Service. Photo point monitoring handbook: part A—field procedures. Gen. Tech. Rep. PNW-GTR-526. 2001.	This handbook describes quick, effective methods for documenting change in vegetation and soil through repeat photography.	1-30
Gold Ridge RCD. Salmon Creek Streamflow Restoration Monitoring: 2013-2016. 2012.	Monitoring strategy for Salmon Creek Water Conservation projects.	1-3
Gold Ridge RCD and Prunuske Chatham, Inc. Salmon Creek Integrated Coastal Watershed Management Plan. 2010.	This Plan takes a watershed approach to address issues of water quality and quantity, rather than looking at stream restoration on a site-by site basis.	7-120
Gold Ridge RCD. Upper Green Valley Creek Watershed Plan: A Living Document to Facilitate the Restoration of Coho Salmon and Preservation of Sustainable Agriculture. 2010	The UGV Watershed Management Plan provides a description of existing watershed conditions, identifies data gaps, identifies and prioritizes sediment reduction and other projects for immediate implementation and provides recommendations for management practices to support agricultural and environmental sustainability.	1-206
North Coast Regional Water Quality Control Board. Water Quality Control Plan for the North Coast Region. 2011.	The need for comprehensive water quality planning is set forth in both California and federal law. California's Porter-Cologne Water Quality Control Act, which is contained in California Water Code, Division 7, Chapters	1-274

	1 through 17, and the Federal Water Pollution Control Act as amended by the Clean Water Act of 1977 require water quality control plans for the waters of the State as well as public review of the plans. The basic purpose of the state's planning effort is to determine the future direction of water quality control for protection of California's waters.	
Dominati, E., Patterson, M., and Mackay, A. A Draft Framework for classifying and measuring Soil Natural Capital and Ecosystem Services. Ecological Economics Volume 69, Issue 9, Pages 1858 – 1868. 15 July 2010.	The ecosystem services and natural capital of soils are often not recognized and generally not well understood. This paper addresses this issue by drawing on scientific understanding of soil formation, functioning and classification systems and building on current thinking on ecosystem services to develop a framework to classify and quantify soil natural capital and ecosystem services. The framework consists of five main interconnected components: (1) soil natural capital, characterized by standard soil properties well known to soil scientists; (2) the processes behind soil natural capital formation, maintenance and degradation; (3) drivers (anthropogenic and natural) of soil processes; (4) provisioning, regulating and cultural ecosystem services; and (5) human needs fulfilled by soil ecosystem services.	1-28
Ekins P., Simon S., Deutsch L., Folke C. & De Groot R. A framework for the practical application of the concepts of critical natural capital and strong sustainability. Ecological Economics 44: 165-185. 2003.	This paper develops a methodology for identifying that natural capital*called critical natural capital (CNC)*the maintenance of which is essential for environmental sustainability. By consideration of the characteristics of natural capital, of the environmental functions that these characteristics enable natural capital to perform and of the importance of these functions to humans and the biosphere, it shows how sustainability standards in respect of these environmental functions may be derived. The difference between the current situation and these standards is termed the sustainability gap. The methodology that emerges from bringing these ideas together into a single analytical framework enables policy makers to identify the extent of current unsustainability, the principal causes of it, the elements and processes of natural capital (the CNC) which need to be maintained or restored to close the sustainability gap and the costs of so doing.	1-20
Ecological Society of America. Ecosystem Services. 2000.	Ecosystem Services are the processes by which the environment produces resources that we often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants. Whether we find ourselves in the city or a rural area, the ecosystems in which humans live provide goods and services that are very familiar to us.	1-2
Gold Ridge RCD. Contractor Certification. 2013.	Contractor Certification concerning state labor standards and prevailing wages.	1



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DRAFTED BY: JP, BKS
CHECKED BY: JP, LH

REVISIONS	DATE	BY

PREPARED FOR:
GOLD RIDGE RESOURCE CONSERVATION DISTRICT

WESTMINSTER WOODS WATER TANK PROJECT

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SHEET 1 OF 2

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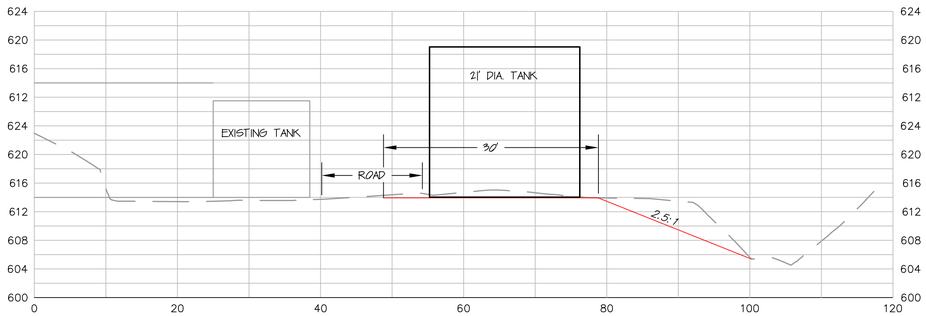

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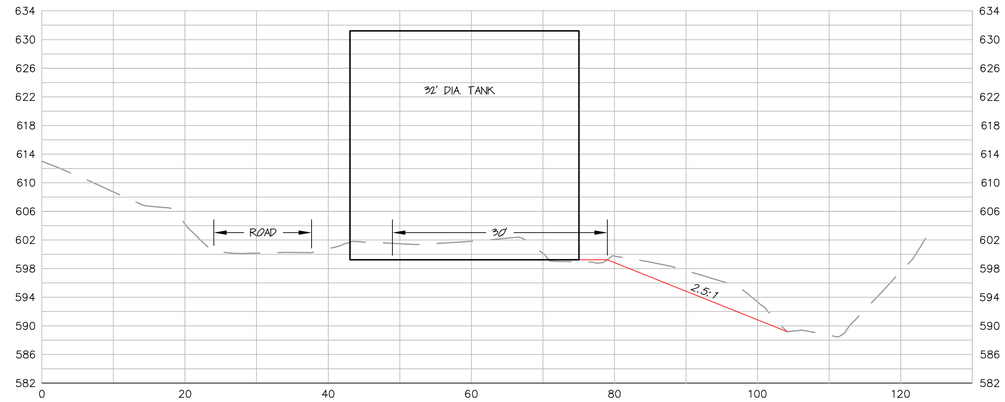

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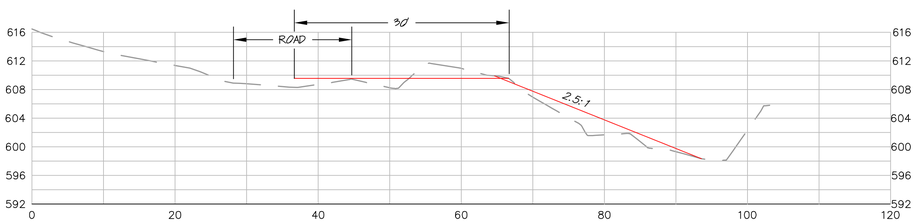

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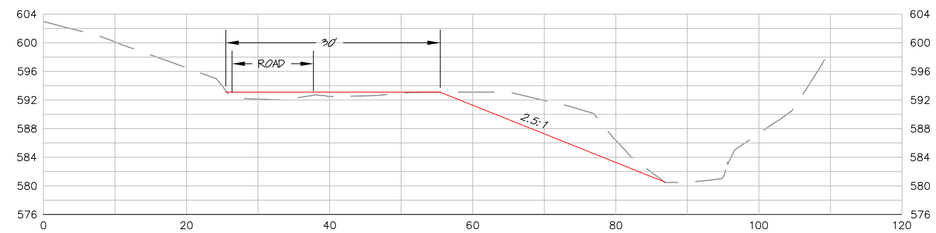

SECTION D-D

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SCALE: AS SHOWN
DESIGNED BY:
DRAFTED BY: BKS
CHECKED BY: JP, LH

REVISIONS	DATE	BY

PREPARED FOR:
GOLD RIDGE RESOURCE CONSERVATION DISTRICT

WESTMINSTER WOODS WATER TANK PROJECT

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SHEET 2 OF 2

[AutoCAD file name: G:\ACAD Drawings\GRRCD\Dutch Bill\Westminster Woods v2008\dwg\Westminster-hc.dwg]
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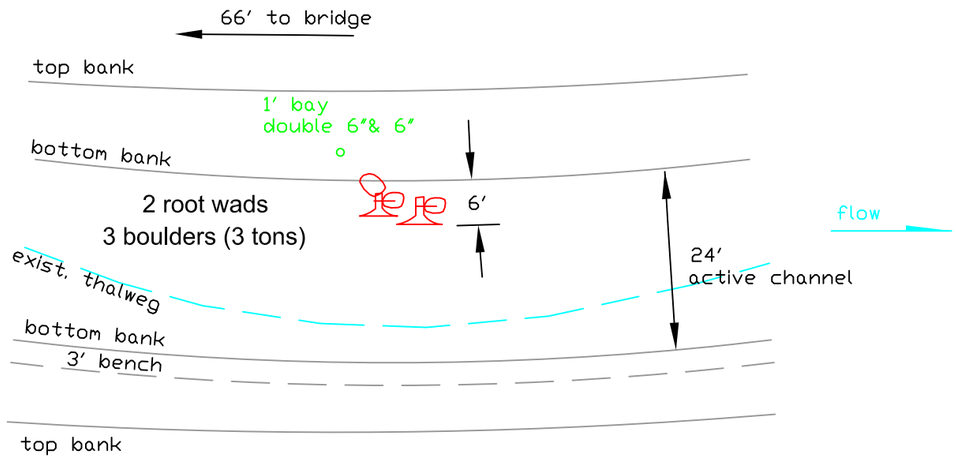
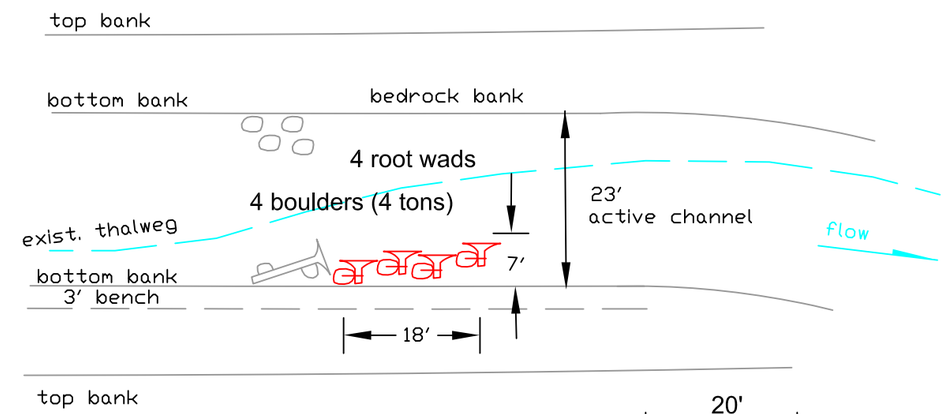


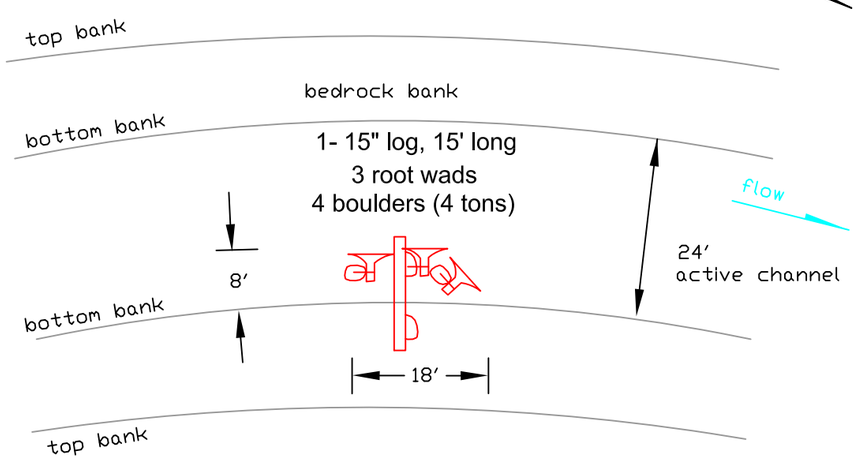
SITE 1
high flow refuge
& pool formation

20′
Graphic Scale



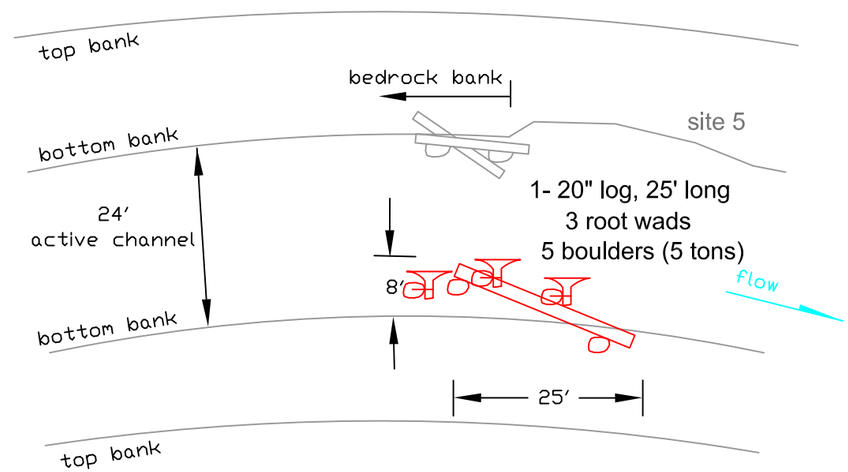
SITE 2
enhance exist. structure
pool shelter
high flow refuge

20′
Graphic Scale



SITE 3
high flow refuge
pool formation
pool shelter

20′
Graphic Scale

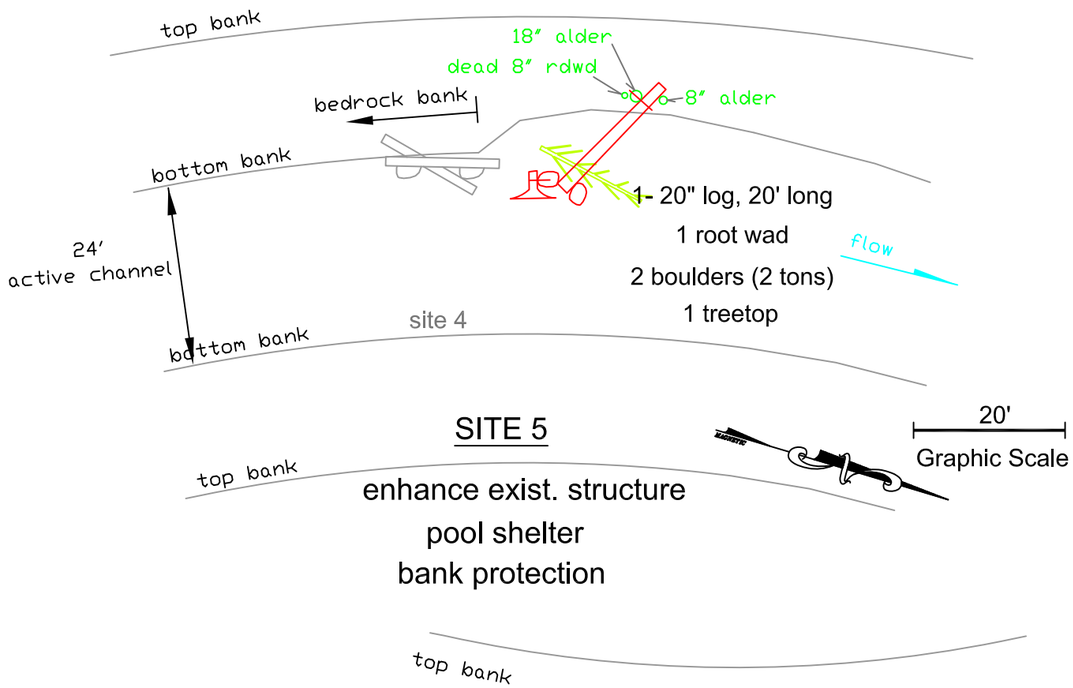


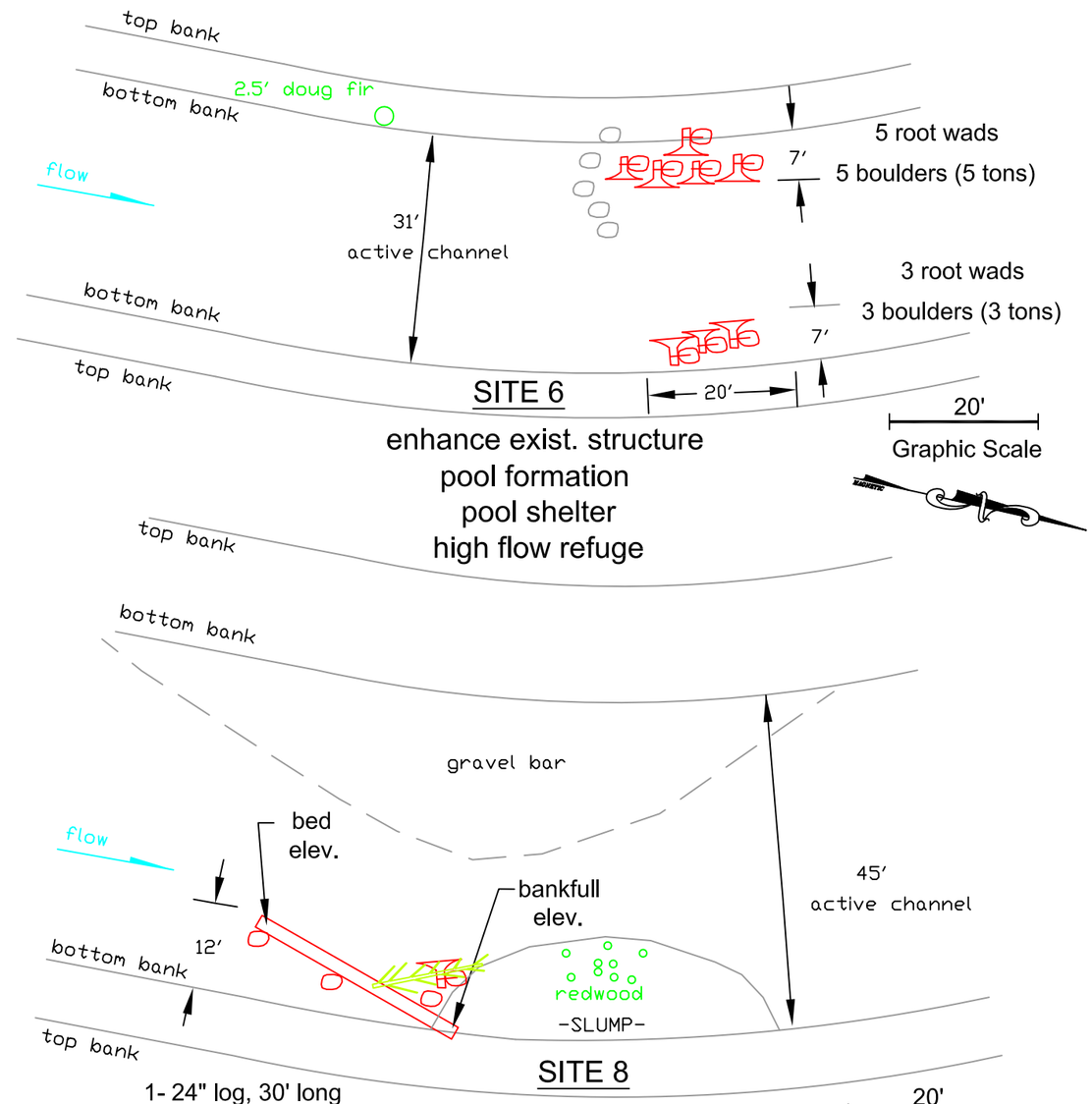
SITE 4
enhance exist. structure
pool formation
pool shelter

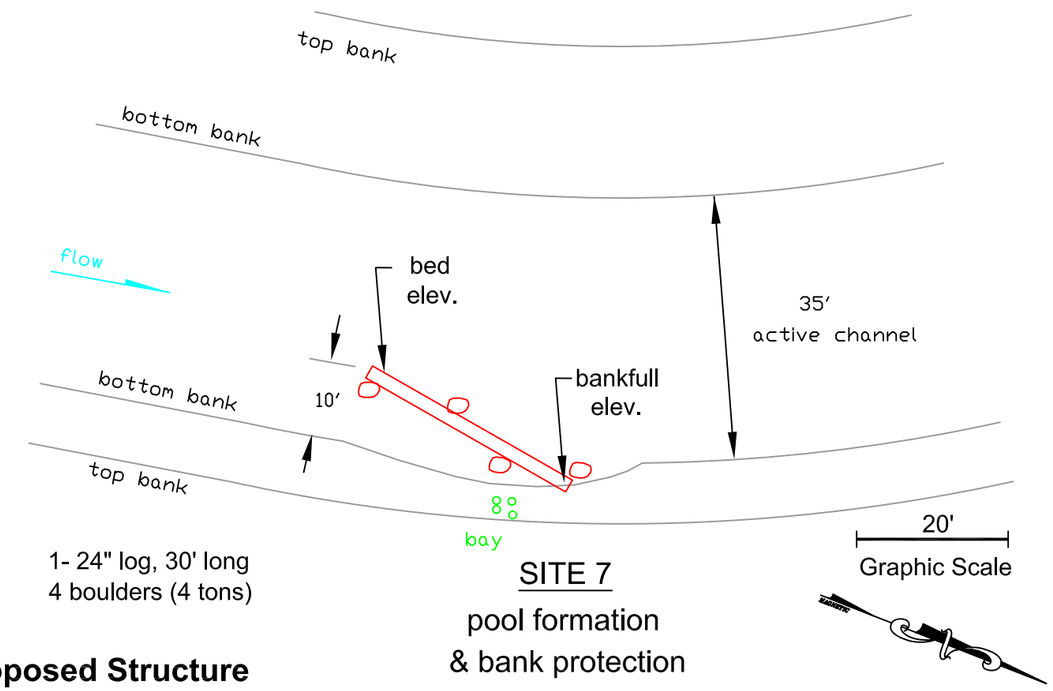
20′
Graphic Scale

Red = Proposed Structure

STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **1** of 7

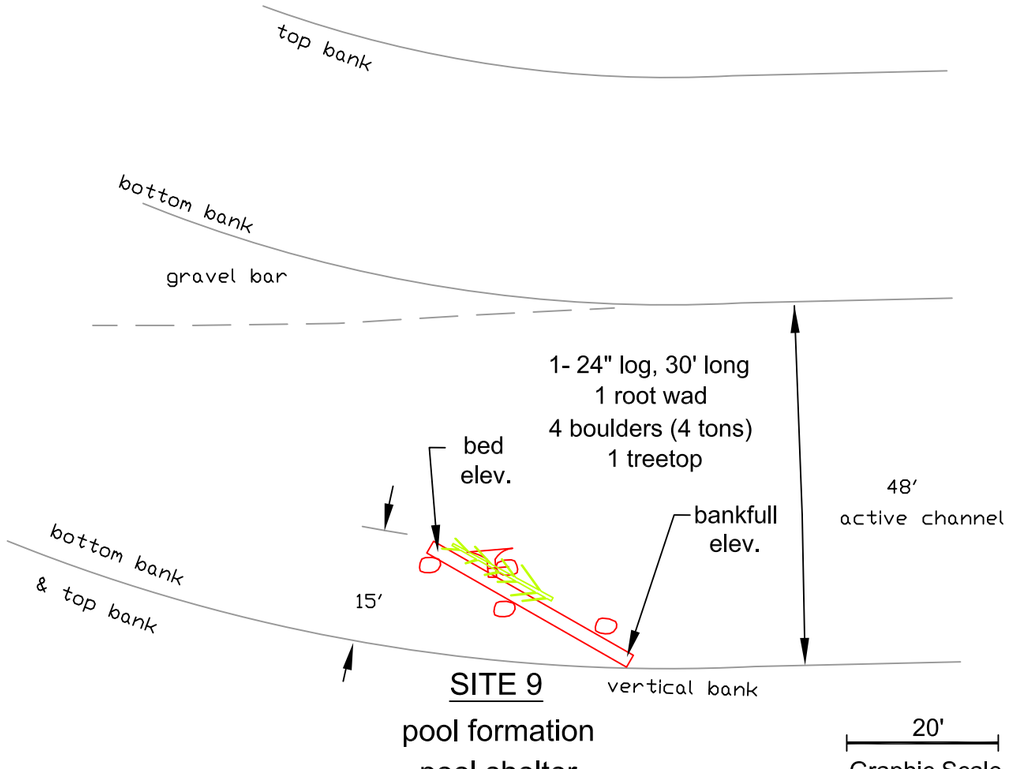






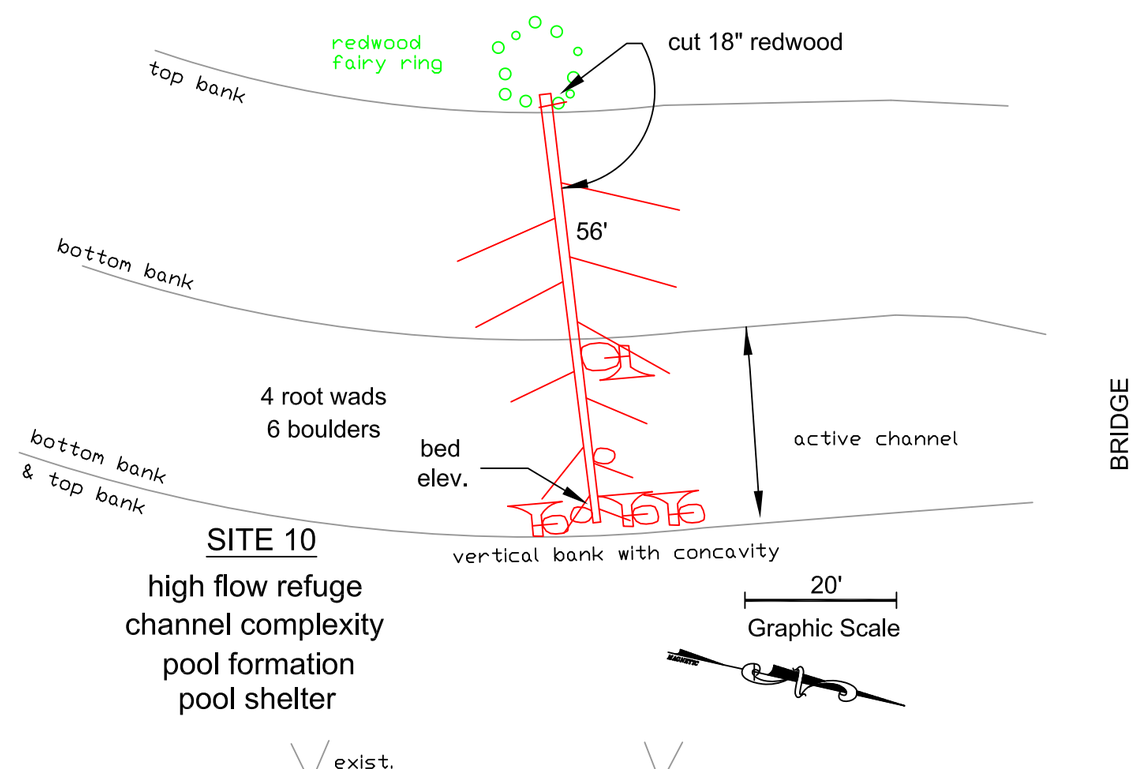
Red = Proposed Structure

STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **2** of 7



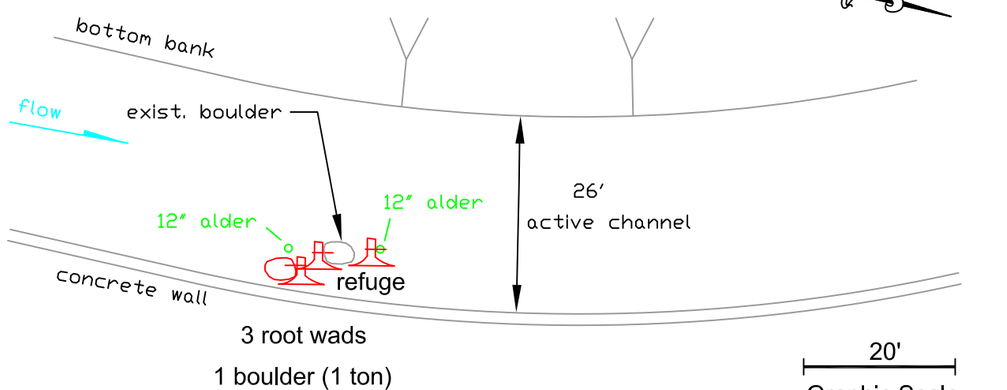
SITE 9

pool formation
pool shelter
bank protection



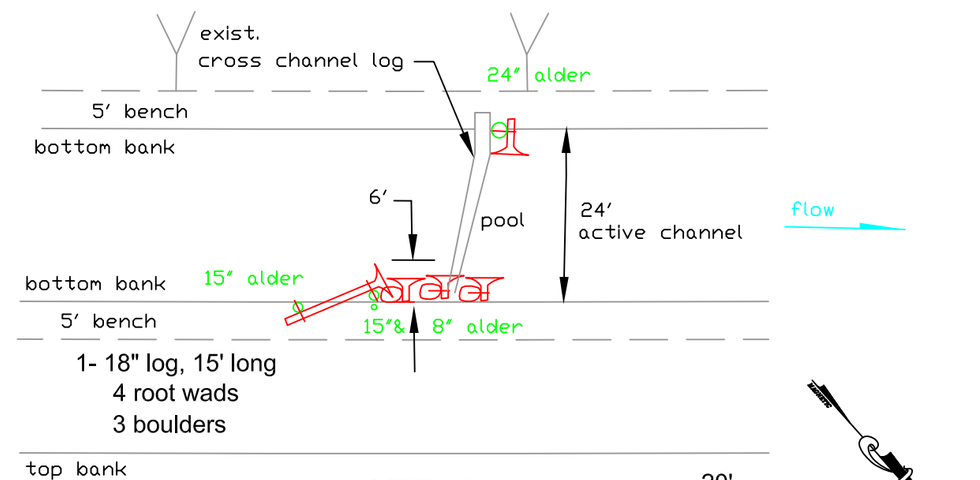
SITE 10

high flow refuge
channel complexity
pool formation
pool shelter



SITE 11

high flow refuge

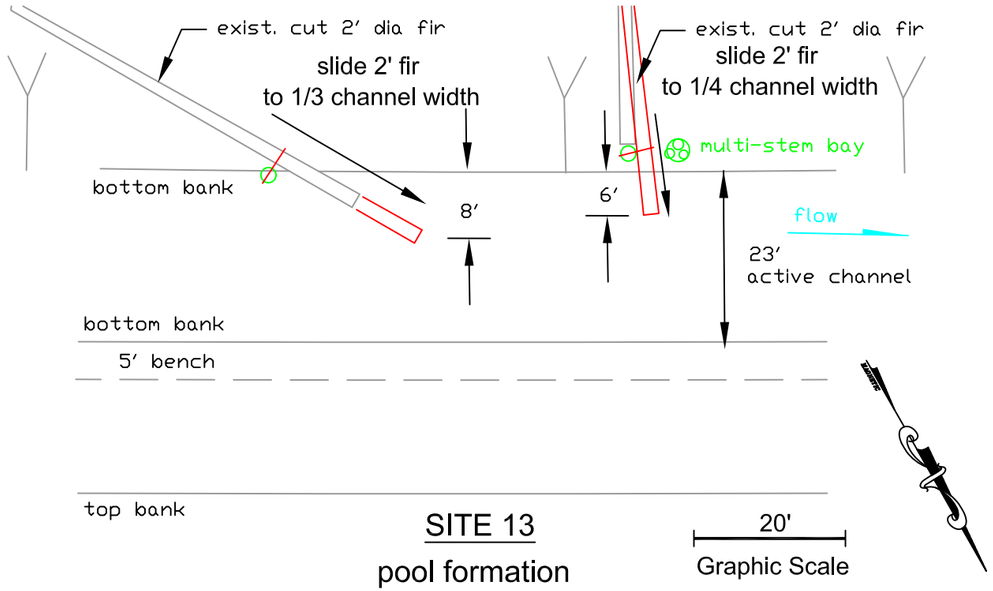


SITE 12

enhance exist. pool
pool shelter

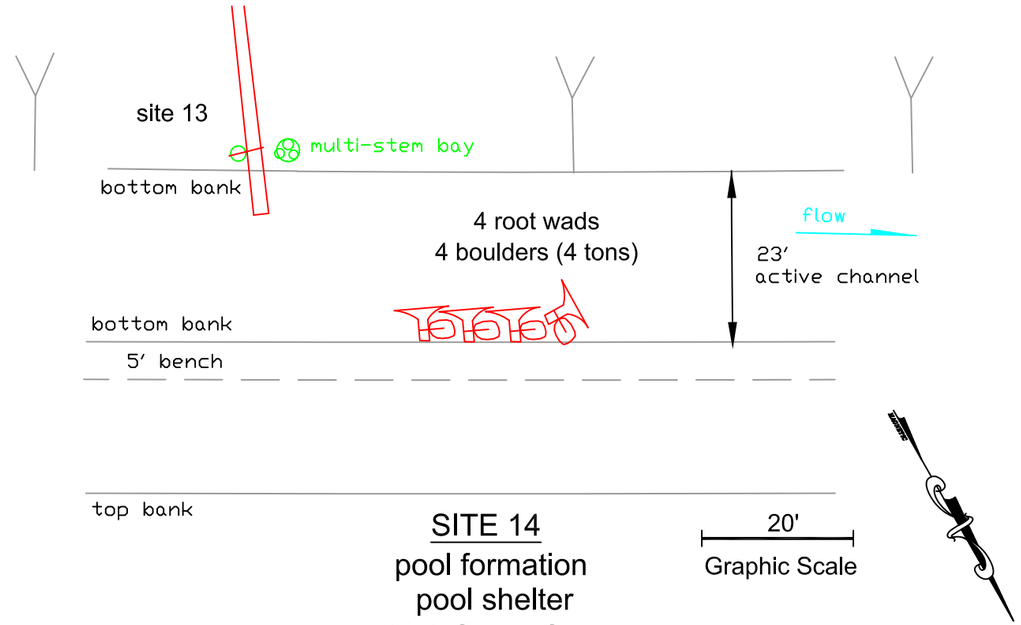
Red = Proposed Structure

STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **3** of 7



SITE 13

pool formation
high flow refuge



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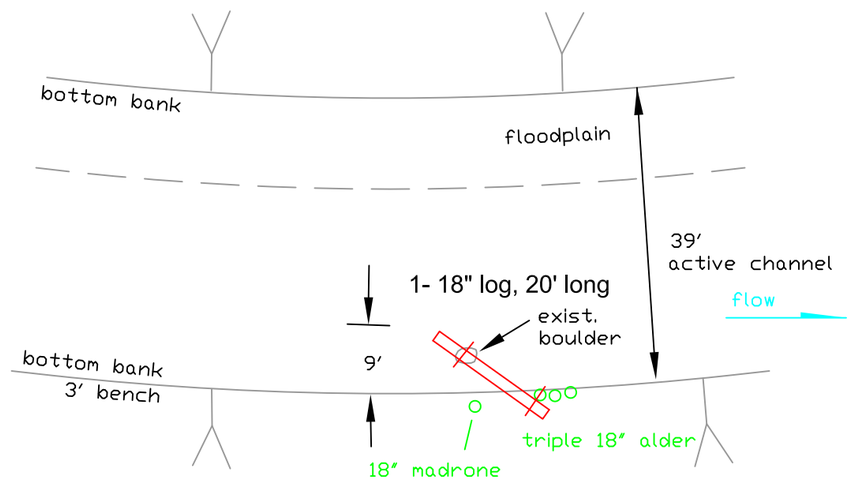
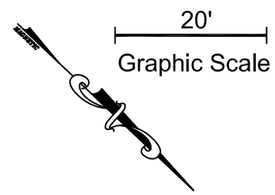
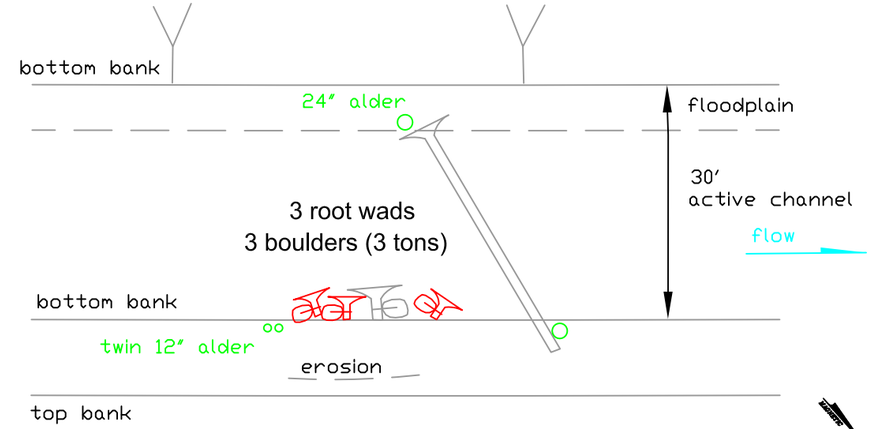
high flow refuge



SITE 15

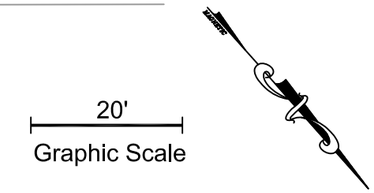
pool formation





SITE 16

enhance exist. structure
pool formation
pool shelter



Red = Proposed Structure

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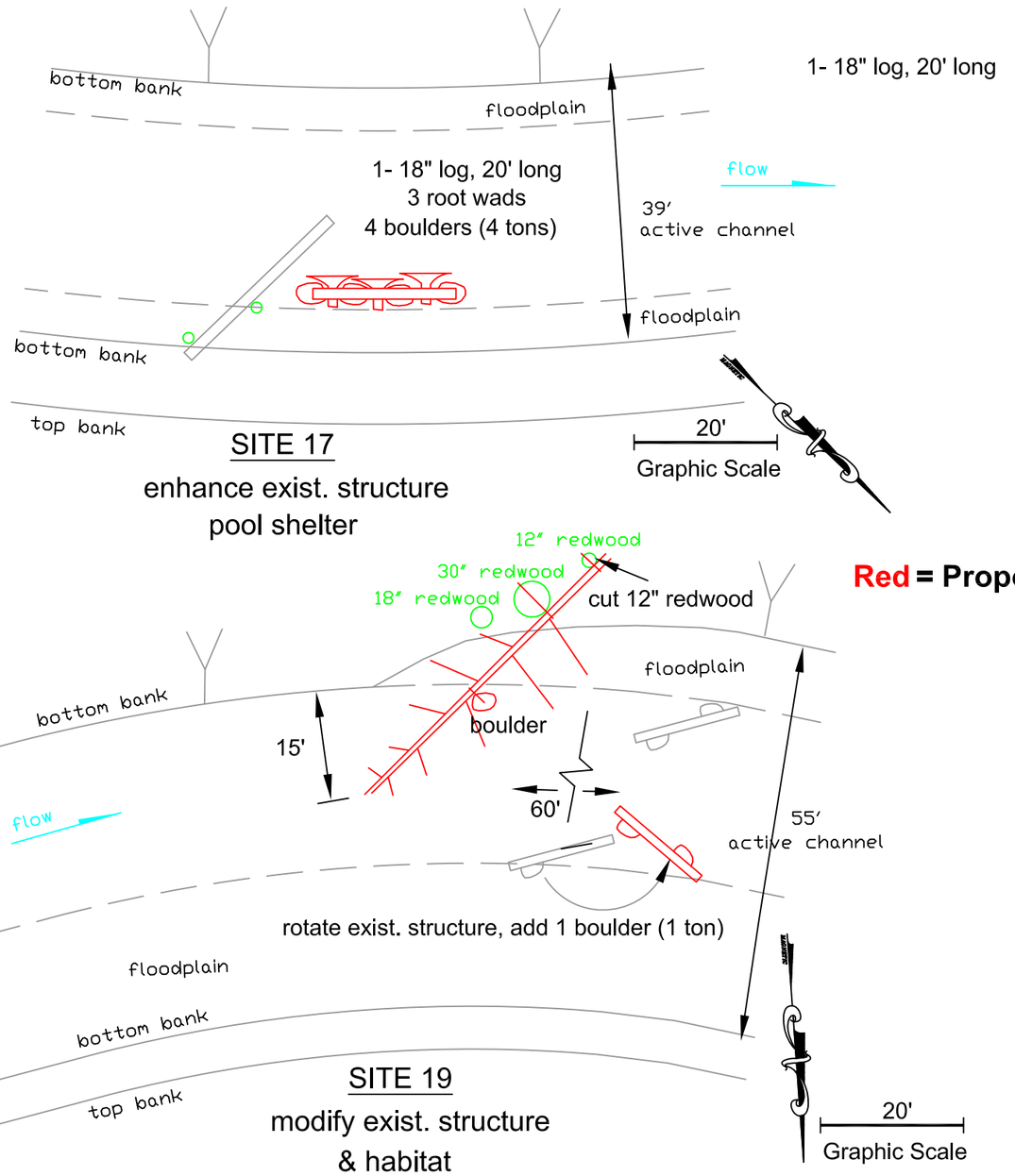
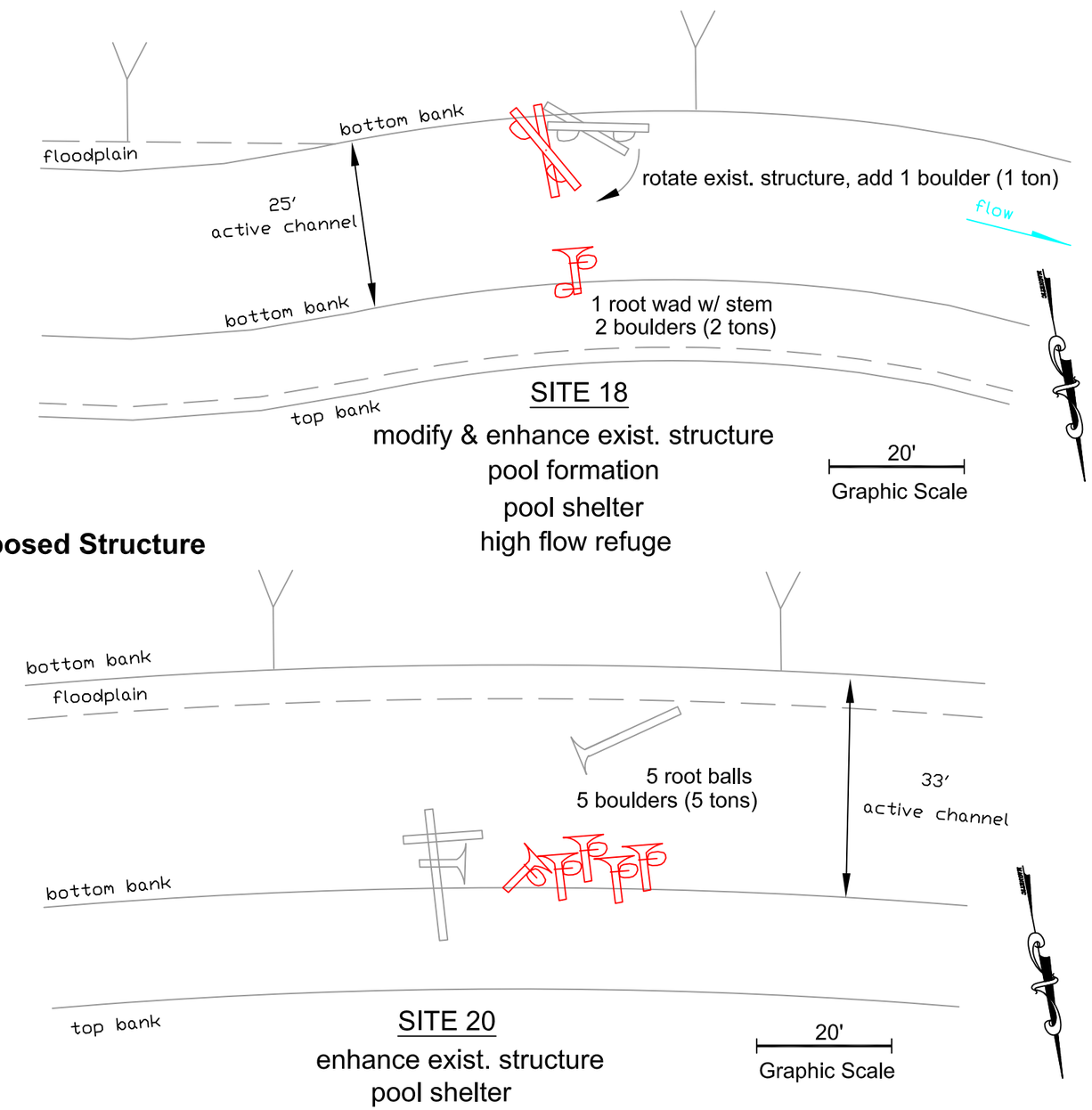


Red = Proposed Structure



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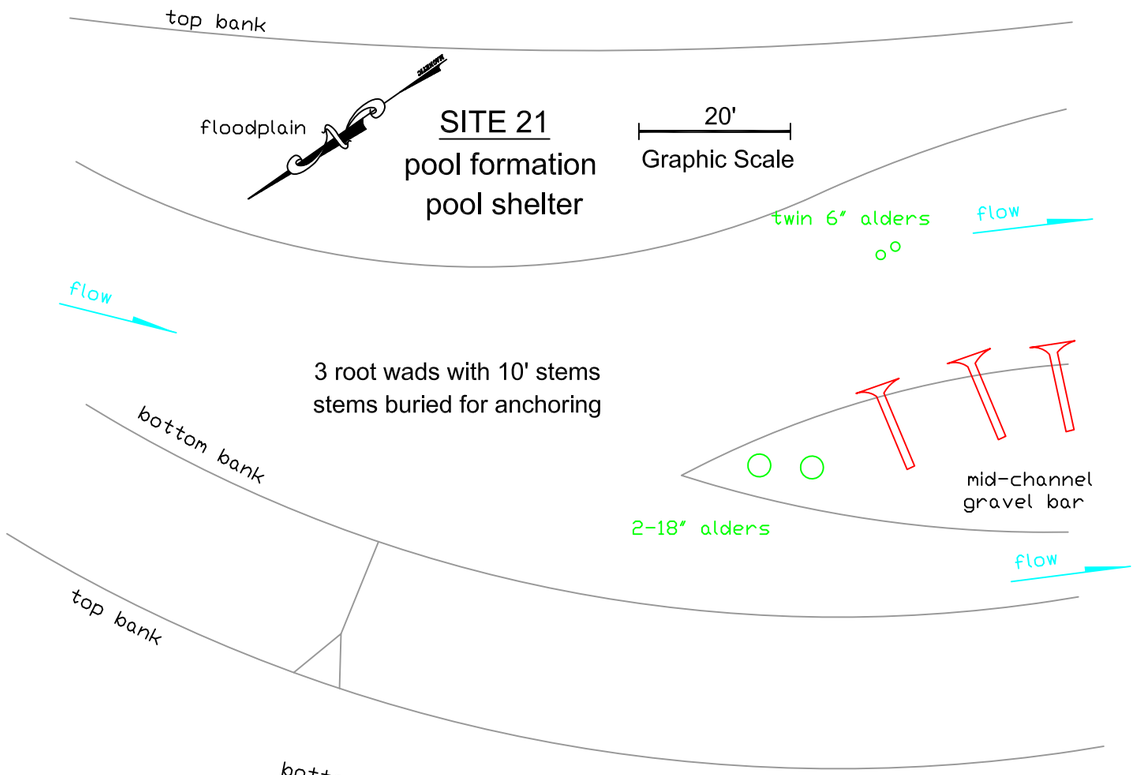

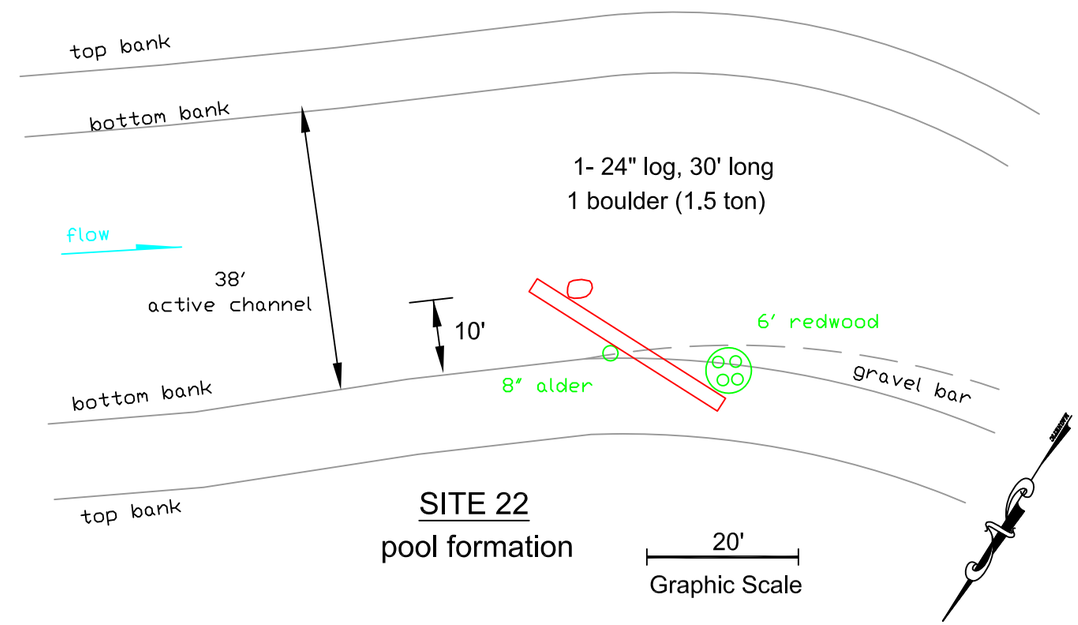

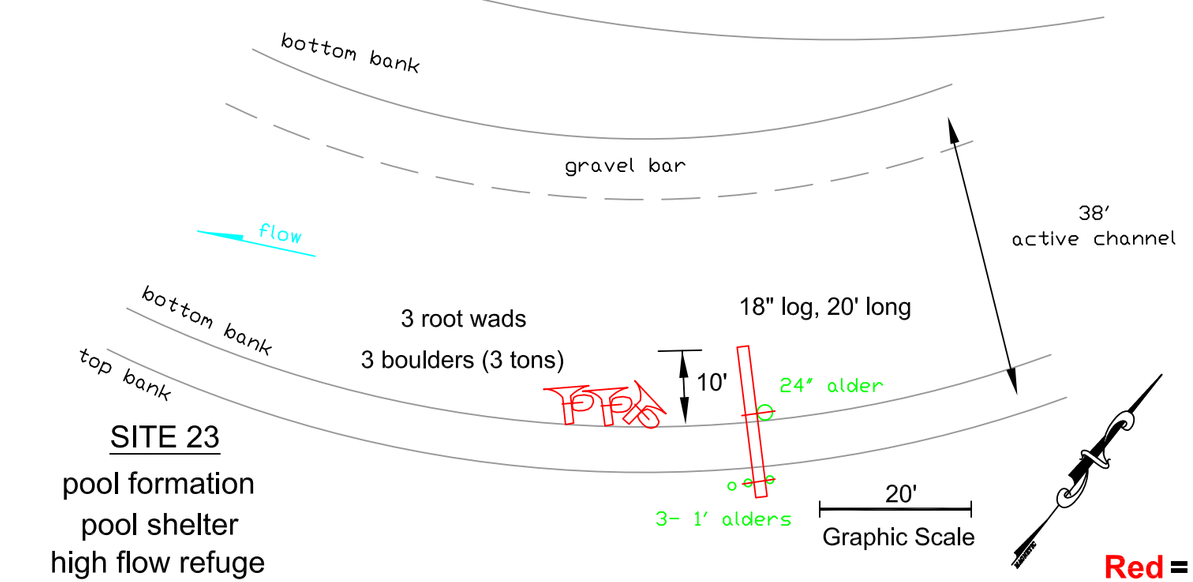

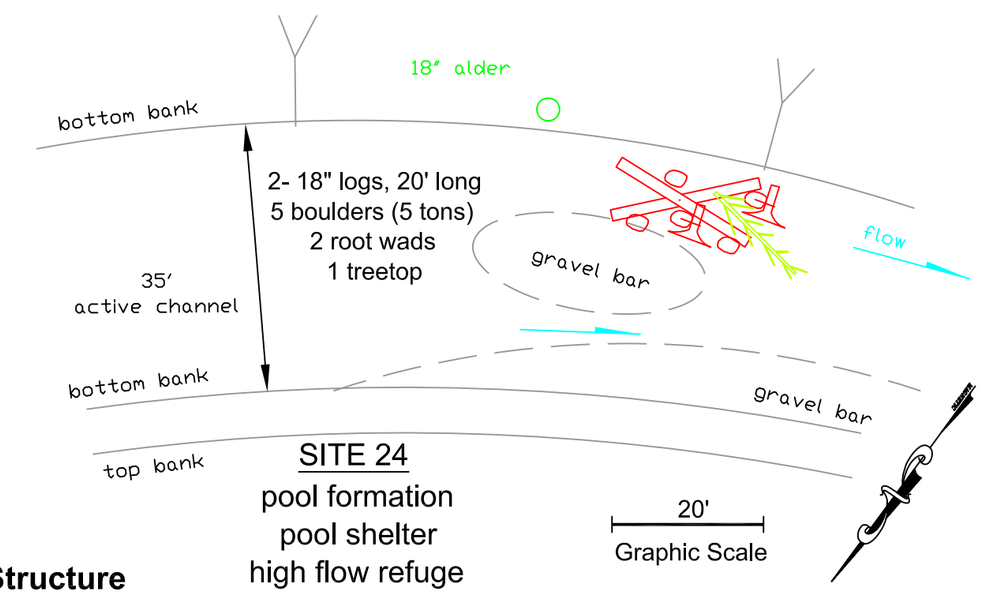

Red = Proposed Structure

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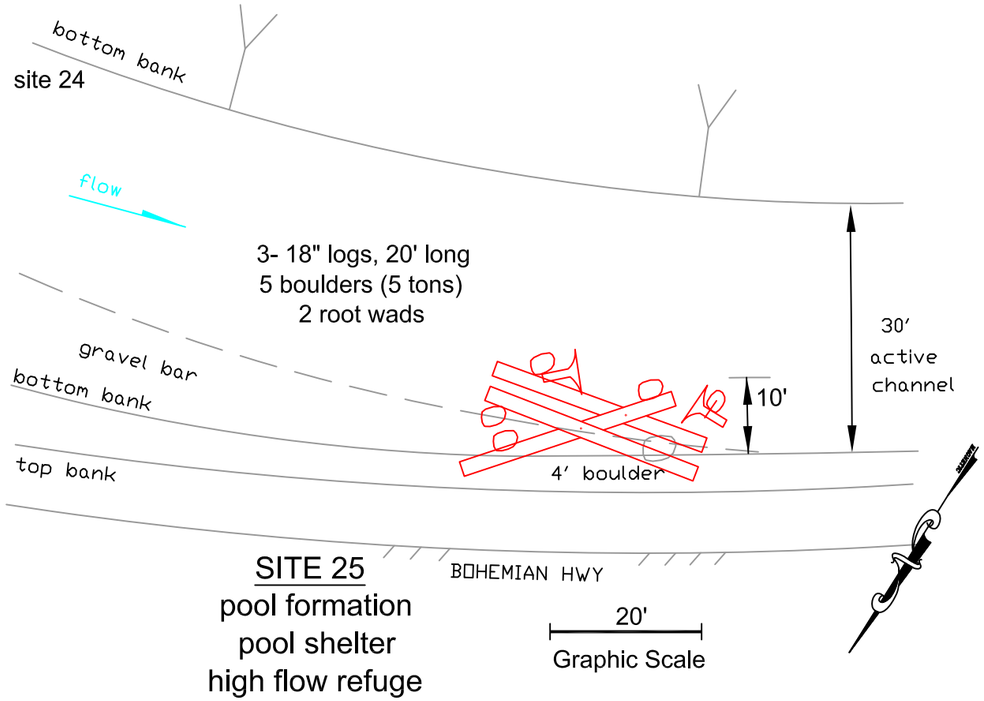
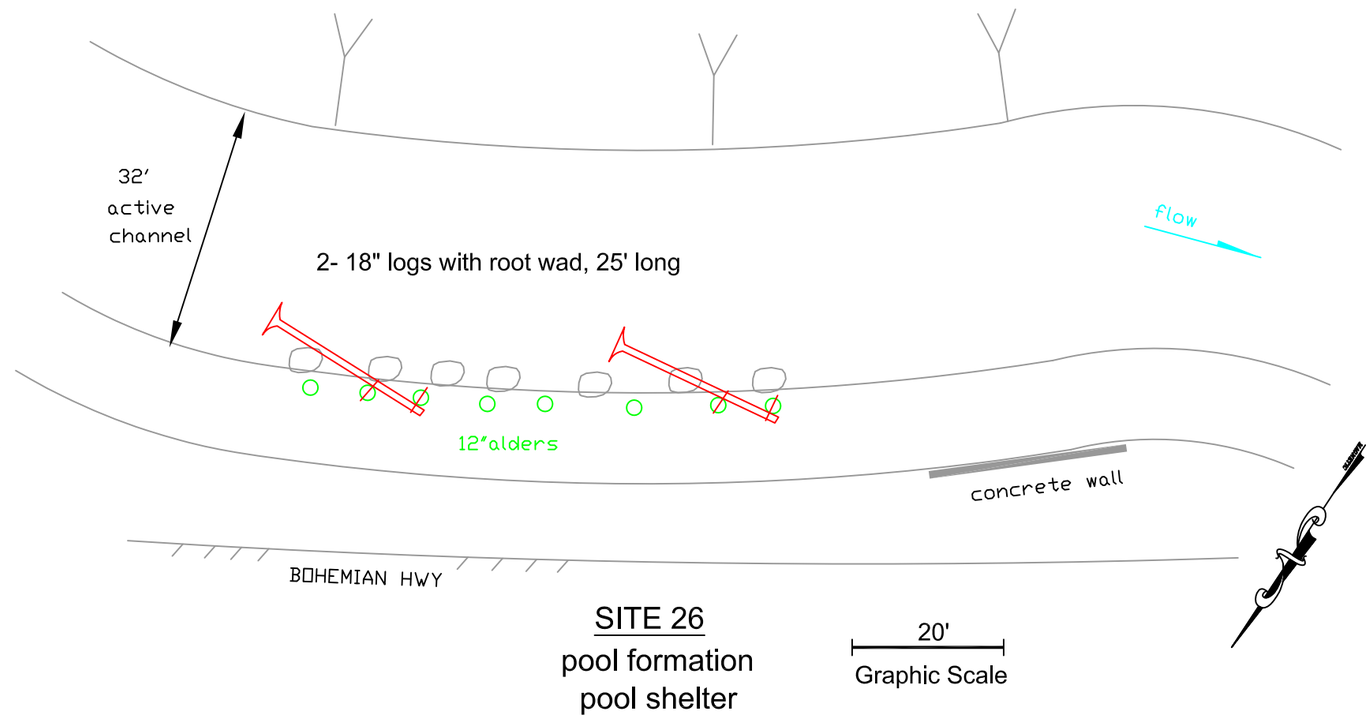
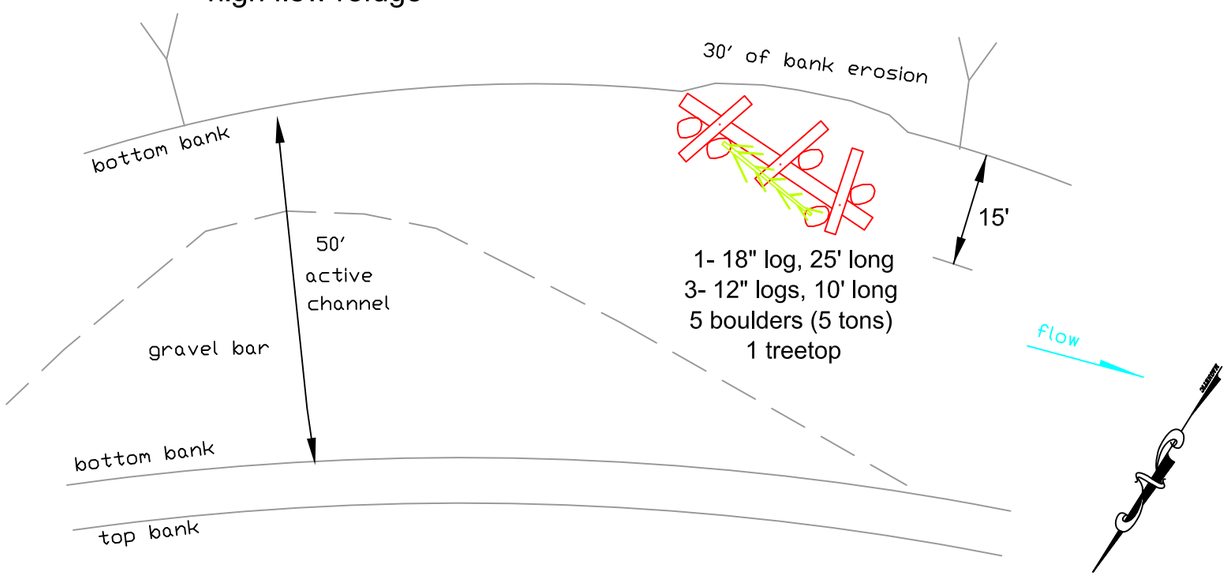


SITE 25
pool formation
pool shelter
high flow refuge



SITE 26
pool formation
pool shelter



SITE 27
pool formation
pool shelter
high flow refuge
bank protection

20'
Graphic Scale

Red = Proposed Structure

STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **7** of 7

Photo Courtesy of Lauren Hammack (PCI)

Salmon Creek Integrated Coastal Watershed Management Plan

June 30, 2010

Developed By:

Gold Ridge Resource Conservation District

PRUNUSKE CHATHAM, INC.

Funding and Oversight Provided By:

Water Boards

Coastal Conservancy

NOAA

RESOURCES AGENCY CALIFORNIA DEPARTMENT FISH&GAME

USDA NRCS

United States Department of Agriculture
Natural Resources Conservation Service

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Most importantly, we would like to thank the landowners who provided us with access to their property so that we could conduct assessments of the creek and its habitats.

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ACRONYMS USED IN THIS PLAN

ARRA	American Recovery and Reinvestment Act
BAEDN	Bay Area Early Detection Network
BLT	Bodega Land Trust
BMI	Benthic Macroinvertebrate
BMP	Best Management Practices
CAFO	Confined Animal Feeding Operation
CAP	NOAA's Conservation Action Planning
CCA	Bodega Marine Life Refuge Critical Coastal Area
CCC	Central California Coast
CCOF	California Certified Organic Farmers
CDFG	California Department of Fish & Game
CNGA	California Native Grass Association
CNPS	California Native Plant Society
DO	Dissolved Oxygen
DPS	Distinct Population Segment
EFH	Essential Fish Habitat
ESU	Evolutionary Significant Unit
GRRCD	Gold Ridge Resource Conservation District
HU	Hydrologic Unit
KRIS	Klamath Resource Information System
LEED	Leadership in Energy and Environmental Design
LID	Low impact development
LWD	large woody debris
MPA	Marine Protected Area
MSWMA	Marin Sonoma Weed Management Area
MWAT	Maximum Weekly Average Temperatures
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	NOAA's National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Agency's Restoration Center
NRCS	USDA Natural Resources Conservation Service
NTU	Nephelometeric Turbidity Units
OAEC	Occidental Arts and Ecology Center
PCI	Prunuske Chatham, Inc.
PRMD	Sonoma County Permit and Resource Management Department
PWA	Pacific Watershed Associates
RWQCB	Regional Water Quality Control Board
SCC	State Coastal Conservancy
SCAPOSD	Sonoma County Agricultural Preservation and Open Space District
SCEIP	Sonoma County Energy Incentive Program
SCICWMP	Salmon Creek Integrated Coastal Watershed Management Plan
SCWA	Sonoma County Water Agency
SCWC	Salmon Creek Watershed Council
SCFCWG	Sonoma County Forest Conservation Working Group
SLT	Sonoma Land Trust
SMCGWG	Sonoma Marin Coastal Grasslands Working Group
SOD	Sudden Oak Death
STRAW	Students and Teachers Restoring a Watershed
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TBD	To Be Determined

TSS	Total Suspended Solids
TU	Trout Unlimited
UAW	Unaccounted For Water Losses
UCCE	University of California Cooperative Extension
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
WMI	SWRCB's Watershed Management Initiative

EXECUTIVE SUMMARY

This *Salmon Creek Integrated Coastal Watershed Management Plan* (Plan or SCICWMP) was prepared jointly by staff at the Gold Ridge Resource Conservation District (GRRCD) and ecological consulting firm Prunuske Chatham, Inc. (PCI) with assistance from the Technical Advisory Committee (TAC). GRRCD and PCI, along with the Salmon Creek Watershed Council (SCWC), initiated the Plan through an application and subsequent award of a Proposition 50 bond-funded grant from the State of California to GRRCD. The grant was awarded in late 2005 and has been administered through the State Water Resources Control Board (SWRCB), with local assistance and direction from the North Coast Regional Water Quality Control Board (NCRWQCB).

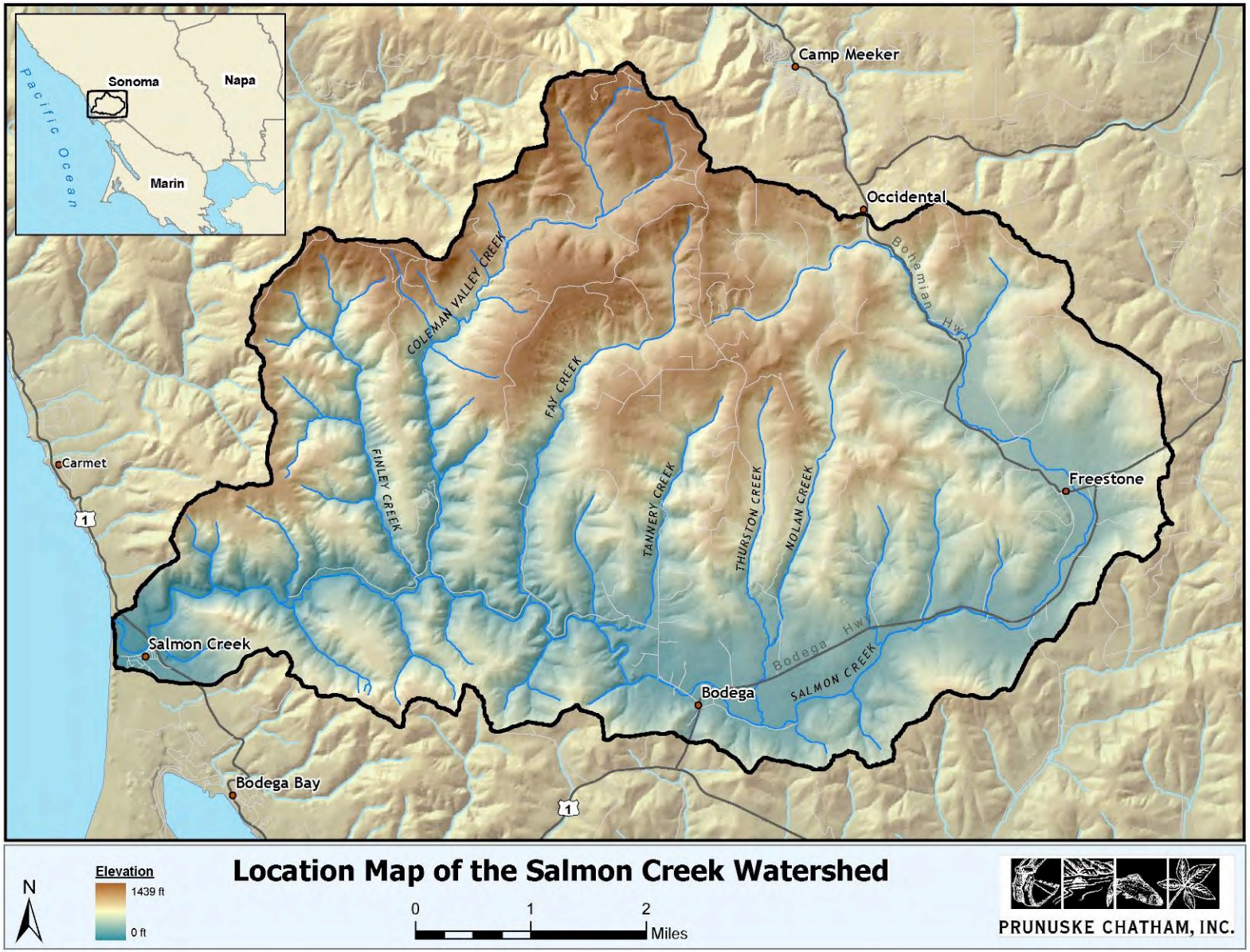
GRRCD provided administration and facilitation of the planning process, while the team, which included staff PCI and the University of California Cooperative Extension (UCCE) provided the science and technical expertise needed to consider the hydrologic boundaries of the subwatersheds, characterize factors limiting the recovery of salmonids in the watershed, and work with the TAC to develop feasible strategies to address all issues. Through a geomorphic assessment, sediment source and water quality analyses, and water supply and demand study, a thorough base of resource knowledge was examined to better understand the current health of Salmon Creek Watershed. Based on these assessments, the Plan contains goals and actions to enhance and protect the natural resources of the watershed for current and future generations.

Salmon Creek Technical Advisory Committee (TAC) meeting. Photo courtesy of Brock Dolman (OAEC)

This Plan takes a watershed approach to address issues of water quality and quantity, rather than looking at stream restoration on a site-by site basis. Because 95% of the land is privately owned, economic viability for the landowners has been a central tenet in the team's planning process, a vital element in sustaining and enhancing the health of the watershed. Also, because the idea of watershed management can mean different things to different people depending on their perspective, the team has worked toward an approach to watershed management in Salmon Creek that will foster an understanding and appreciation of the landowners and their contribution toward land stewardship.

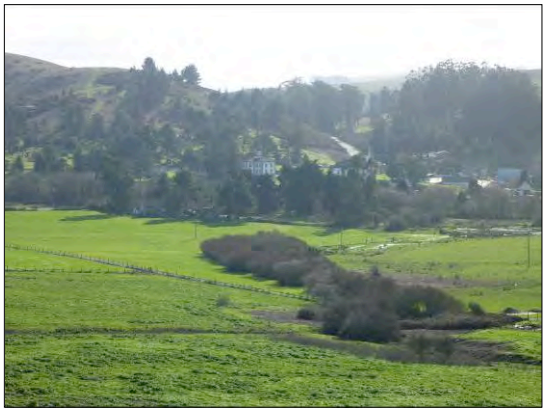
The Plan should be viewed as a "living document." The goals and actions included in this plan are based on our current level of understanding of the ecological processes and health of the watershed. It is expected that management issues and priorities will change through time, and stakeholders will adapt this plan and subsequent recommendations as conditions change.

Figure 1. Salmon Creek Watershed location map.



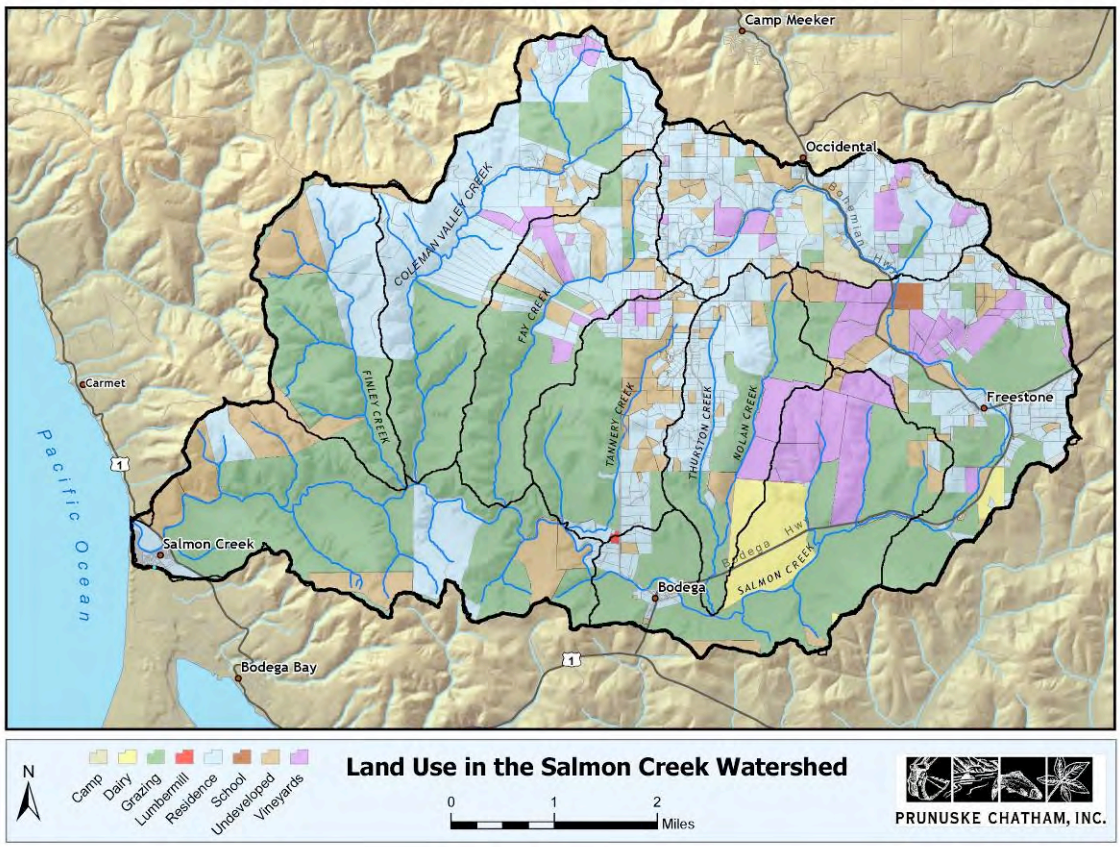
CHAPTER 1: INTRODUCTION

Background



The Salmon Creek Watershed covers approximately 35.3 square miles in coastal Sonoma County and is a salmonid-bearing stream that drains to the Pacific Ocean immediately north of the Bodega Marine Life Refuge Critical Coastal Area (CCA). Salmon Creek has 6 major north-south trending tributaries: Finley, Fay, Tannery, Nolan, Thurston, and Coleman Valley Creeks. The watershed also contains 17 unnamed, smaller tributaries. From its highest point at 797 feet, the mainstem of Salmon Creek runs south through Occidental and makes a westerly curve near Freestone before reaching the ocean 3 miles north of Bodega Bay. The watershed's terrain is characterized by steep topography and soils that are highly erosive and sensitive to disturbance. Vegetation occurring in the watershed is a combination of deciduous and mixed coniferous forests and grasslands.

Figure 2. Land use in the Salmon Creek Watershed.



The Salmon Creek Watershed is almost completely privately owned (95%). Primary land uses include rangeland, viticulture, timber, rural residential, and urban. Current and historic land-use activities have degraded the natural environment, impaired water quality and aquatic habitat, and increased the rate and amount of sedimentation.

The watershed once had a thriving anadromous fish population, vibrant stands of vegetation, and exceptional water quality. (See Figure 1. Salmon Creek Watershed Location Map.) The precipitous decline in salmonid populations in the watershed has all but decimated the local fishery, once a key local industry. Although Salmon Creek is not on the federal Clean Water Act §303(d) list of impaired waterbodies, it is an important coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Onchorhynchus mykiss*) stream. The SWRCB's Watershed Management Initiative (WMI) states that "concerns have been raised by the public regarding increased sedimentation, water temperature, nutrients, and salmonid habitat" in Salmon Creek.

However, the California Department of Fish and Game (CDFG) considers Salmon Creek[1] a fully restorable salmonid stream (CDFG 2004d). In both December 2008 and 2009, CDFG reintroduced approximately 500 adult coho salmon into the creek as part of their broodstock program. In the face of climate change and a sharp regional decline in salmonid populations over the past two years, the stakes for supporting the newly reintroduced coho salmon and the returning steelhead trout are very high.

The Salmon Creek Watershed is becoming regionally renowned for its forward thinking, collaborative, non-regulatory driven restoration program and is often cited as a model for other watershed efforts. In 2005, GRRCD received grant funding from the SWRCB to develop the *Salmon Creek Integrated Watershed Management Plan* (Plan). The Plan strives to integrate environmental management, natural resource protection, agricultural sustainability, and community goals to provide a guide for improving watershed health.

The planning process has been a multi-faceted, multi-partner program, begun in earnest, to address poor habitat conditions in the Salmon Creek Watershed through prioritized implementation and long-term outreach and education. The goal of this plan is to develop a program that, if implemented effectively, will improve the rankings of several key habitat condition indicators (e.g., summer rearing baseflow, primary pools and shelter, large woody debris (LWD), and turbidity), currently ranked as "Poor" for coho salmon using NOAA's "Conservation Action Planning" (CAP) process (NOAA Fisheries, Southwest Region, 2009 draft in press), to "Good." Activities to date include development of a watershed-wide water supply planning, management and outreach program aimed at reducing impacts to streamflow and water quality, installation of estuary habitat structures to increase smolt rearing success, road and gully fine-sediment reduction projects, instream habitat (LWD) improvement projects, and riparian revegetation and fencing.

[1] Salmon Creek is located within the Bodega Hydrologic Unit (HU) in the CCC Evolutionary Significant Unit (ESU). Salmon Creek is part of the Sonoma Coast State Marine Conservation Area, a State Marine Protected Area (MPA) (California Marine Life Protection Initiative 2007.

Vision

The Plan offers the following vision for the Salmon Creek Watershed and its tributaries:

> *The Plan reflects common ground between landowners, program partners, and resource agency staff. The primary aim of this Plan is to better understand and address the conditions necessary for ensuring a healthy and functioning watershed ecosystem, to develop a program to improve habitat for native species, and to promote conservation oriented land management practices while safeguarding the economic viability of the watershed's agricultural heritage.*

Salmon Creek Watershed Planning Meeting, December 1, 2009

Planning Process

The Plan is the culmination of years of commitment by landowners (both agricultural and rural residential), SCWC, Occidental Arts and Ecology Center (OAEC), LandPaths, PCI and GRRCD, as well as agency staff from CDFG, State Coastal Conservancy (SCC), NCRWQCB, the USDA Natural Resources Conservation Service (NRCS), the University of California Cooperative Extension (UCCE), and the National Oceanic and Atmospheric Agency's Restoration Center (NOAA). Each of these groups was represented during the planning process at Technical Advisory Committee (TAC) meetings, which were held quarterly except for a one-year period when the State of California experienced a severe fiscal crisis, and planning efforts had to be put on hold. The TAC included members with expertise in hydrology, geomorphology, biology, fisheries, water quality science, agriculture, watershed education, and conservation planning.

Each TAC member offered a unique set of skills and knowledge, and, although there was some disagreement, everyone was respected and heard. Local rural residential and agricultural landowners provided history and familiarity to ensure an accurate representation of land use in the watershed. Other members offered organizational direction, funding, and technical expertise. All members contributed to the planning vision, goals, recommendations and actions presented in this plan. GRRCD, as the lead agency, was responsible for creating an atmosphere of trust that allowed groups with varying interests to learn from the others' points of view.

A History of Partners in Stewardship

> *The Salmon Creek Integrated Watershed Management Plan represents a significant step towards a more cooperative results-focused way to protect our natural resources that incorporates local values and knowledge in a way that sustains our local agricultural community, the economy, and the environment.*

Residents, local watershed groups, and public agencies have worked to assess the ecological health and functioning of the Salmon Creek Watershed and to document specific sites and/or activities that may be degrading the riparian system and impairing critical fish habitat.

The partners involved in this planning process were originally brought together in 2003 by funding from CDFG to GRRCD to perform a baseline assessment and develop a "plan of action" for stream restoration activities in the watershed. This first planning grant was envisioned by the SCWC and resulted in the *Salmon Creek Watershed Assessment and Restoration Plan* (PCI and GRRCD 2007). The grant helped build the organizational capacity of GRRCD and led to implementation of priority conservation projects throughout the watershed.[2]

Planning efforts continued through funding from SCC to OAEC, which produced the *Salmon Creek Estuary Study and Enhancement Plan* (PCI 2008) and led to the ongoing Salmon Creek Water Conservation Program. The *Salmon Creek Water Conservation Plan* (PCI et al. 2010) presents strategies and recommendations to increase dry-season flow while supporting the freshwater needs of residents. Assessments of watershed and stream conditions have also been completed (CDFG 2002; PCI 2006; GRRCD 2007). The collaborative spirit of the SCWC helped rally landowners together to participate in an assessment of rural roads (PWA and GRRCD 2008). This continuity of public input has allowed the core project team (consisting of landowners, SCWC, PCI, and GRRCD) to provide a vision for protecting and improving the condition of the watershed.

The team understands that agriculture is an important mainstay of the local economy. Agricultural producers in our coastal watersheds are under dual pressures of increasing regulatory oversight and the competitive demands of the marketplace. We believe that sustainable ranching and livestock productions can maintain a living, while at the same time improve the overall conditions of soil, water, grasslands, and riparian resources. The financial benefits of sustainable ranching include reductions in property loss due to soil erosion, improved forage production, improved livestock health, higher product values, market diversification, and greater market accessibility. Chapter 7 provides a more detailed strategy for improving the health of the watershed and the long-term preservation of its habitats and natural capital through a continued partnership with the agricultural community.

Planning Goals and Objectives

Land-use practices in the Salmon Creek Watershed have resulted in altered stream channels, reduced riparian zones, and reduced access to suitable spawning habitat. Streambank alterations have resulted in a loss of natural habitat complexity (i.e., riffles, pools, and other *refugia*), effectively limiting the capacity for freshwater streams to serve

[2] Salmon Creek Ranch Enhancement Design and Implementation Grant Agreement Nos. 03-005, 06-027 and 06-115 (State Coastal Conservancy); Bodega Coastal Streams Restoration Project Agreement No, 03-175-110 (State Water Resources Control Board); Save Our Salmon – Salmon Creek Habitat Rehabilitation Program –Phase I NA09NMF463236 (NOAA Restoration Center); Mache Ranch Stream Restoration I and II, Fay Creek Revegetation Project, and the Salmon Creek Roads Assessment Project (CDFG).

as spawning, rearing, and migratory habitat for a viable coho salmon population. The removal of riparian vegetation has caused increases in temperature and fine sediment, as well as reduced instream complexity as a result of fewer sources of LWD.

If coho salmon recovery in the watershed is to be realized, there is no doubt that targeted actions need to be taken.

Fay Creek "Young of the Year", June 29, 2009.
Photo courtesy of Joe Pecharich (NOAA Restoration Center)

Some of the existing limiting conditions in the watershed include:

- High turbidity and sediment loads from roads and riparian and gully erosion;
- Low streamflow during the dry summer months;
- Poor instream habitat from lack of channel complexity; and
- High summer water temperatures from lack of adequate canopy cover.

However, the team has reached consensus that the Salmon Creek Watershed ecosystem can be considered healthy and functioning if we achieve the following goals and can measure results. All may not be achievable in the current generation, or our children's generation, but we must strive to achieve the ideals outlined below.

1. **Water supply in the Salmon Creek Watershed is adequate for the needs of the landowners and the ecosystem.**
   The amount of the streamflow in the tributaries and in the mainstem of Salmon Creek support the ecosystem such that:
   - Freshwater quantity is sufficient to support the needs of the rural residential and agricultural landowners.
   - Freshwater quantity is sufficient to support the needs of the native terrestrial and aquatic ecosystems.

2. **Water in the Salmon Creek Watershed is clean and of consistent high quality.**
   Water in the tributaries and in the mainstem of Salmon Creek meets or exceeds regulatory requirements, and both point and nonpoint pollution sources have been reduced in order to support freshwater, estuary, and upland ecosystems.
   - Sediment loading does not exceed the level consistent with the requirements of fish and other aquatic species.

- Nutrient pollution from human and other sources is minimized to the point that it is no longer detectable in fresh water.
- Loadings of any pollutant do not exceed levels that may impair healthy ecosystem functions.

3. **The quality of life for residents in the Salmon Creek Watershed is supported by a healthy and functioning ecosystem.**
   A healthy Salmon Creek Watershed can support the social and economic vitality of its landowners.
   - The natural resources of the Salmon Creek Watershed are ample enough to support agriculture, fisheries, forestry, and tourism.
   - The Salmon Creek Watershed's economic prosperity is compatible with the protection and restoration of a healthy and diverse ecosystem.

4. **Stewardship activities in the Salmon Creek Watershed build and support landowner capacity to protect and sustain the environment.**
   Landowners and decision makers have the information and resource capacity necessary to monitor ecosystem health.
   - Landowners are provided with the education and technical support needed to make proactive local decisions regarding water resources.
   - Coordinated strategies are supported and encouraged at all levels of government.
   - GRRCD, other local nonprofits, and conservation-minded organizations are supported and funded in order to participate in collaborative processes at the ecosystem level.

Plan Contents

GRRCD's grant agreement with the SWRCB scope defines individual elements that the Plan will address. The Plan will strive to:

- Define the watershed vision;
- Define watershed goals, distinguishing between short- and long-term;
- Identify the watershed stakeholders and enroll them in the Plan development process;
- Define the geographical and jurisdictional boundaries of the watershed;
- Describe current watershed conditions through assessment and data integration;
- Develop proposed actions and implementation strategies necessary to achieve watershed goals;
- Identify the persons, organizations, and public agencies responsible for implementing the proposed actions, and enroll them in the watershed improvement projects;

- Outline a schedule and plan for implementing proposed improvement actions with realistic time frames and target dates and a process for adapting the Plan over time;
- Establish a program for project and watershed improvement measure effectiveness monitoring; and
- Establish a system for evaluating and responding to proposed projects based on impacts on natural resources and beneficial uses.

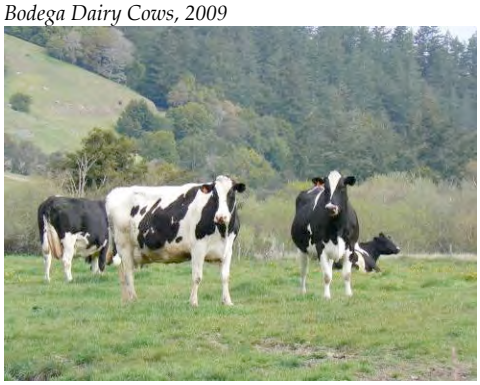
The Plan describes actions for addressing watershed issues and for providing future opportunities for multiple organizations and the community to become involved in restoration and recreation activities in the streams. Stakeholders in the Salmon Creek Watershed have been actively involved in identifying the issues and developing the Plan's goals, objectives, and actions. The following chapters identify pertinent natural resource goals and context, along with implementable actions and the scientific basis for those actions. The integrated watershed approach combines several management strategies to achieve sediment load reductions, water conservation, and riparian and instream habitat improvements throughout the Salmon Creek Watershed. In addition, watershed-wide, landowner-driven erosion prevention, education, restoration and revegetation, better agricultural practices, and other improvements, such as new zoning regulations and enhanced opportunities for easements, will be needed for long-term success.

Conclusion

A large part of the work that went into developing this plan involved characterizing and assessing the ecological processes of the watershed based on both a compilation of existing studies, as well as the creation of new information derived from field analysis of geomorphic and water quality conditions and land uses. Numerous interviews were conducted with watershed residents over the course of this planning study to gain valuable information about historical changes in the watershed and the value of its resources.

The implementation of the Plan is one of many steps that still need to be taken and is designed to be a living and adaptable document that will be updated as necessary over the 10-year implementation schedule. The Plan will not solve all the outstanding issues of the watershed, but it can serve to guide the State of California, County of Sonoma, GRRCD, other conservation-oriented organizations, landowners, and resource agencies in the right direction.

Bodega Dairy Cows, 2009



Bees as part of Gold Ridge RCD Pollinator Program, 2009

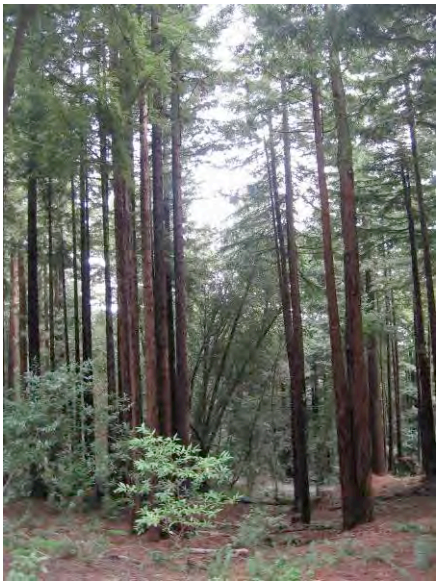
CHAPTER 2: STATE OF THE WATERSHED

Introduction

From mature redwood forests to coastal dunes, the Salmon Creek Watershed contains a remarkable diversity of habitats for its size. With no major water impoundments, minimal urban development, and many concerned and active residents, the watershed presents excellent opportunities to address issues common throughout northern coastal California. The watershed's forests, streams, grasslands, and estuarine habitats all face challenges from historical and recent human impacts. They also support many listed plant and animal species, as well as working forests, vineyards, ranches, and dairy operations that depend upon well-functioning ecosystems for long-term viability. This chapter briefly describes current conditions of Salmon Creek habitats, along with key wildlife and plant species.

Uplands

Salmon Creek Watershed marks the southern boundary of the extensive mixed evergreen forests of Sonoma and Mendocino Counties. The five main tributaries and the headwaters of Salmon Creek drain high, steep, forested ridges and canyons. They flow into the open, rolling grasslands that typify the countryside to the south through which the middle portion of Salmon Creek traverses. The low ridges that form the southern boundary of the watershed are mixed grassland and coastal scrub communities. Coastal terrace grassland and dune communities occur near the coast. The diverse, multi-layered canopies and root systems of these native communities soften the erosive impact of rainfall on the land, protecting downstream water quality, and help absorb and store water, recharging aquifers. The diversity of the Salmon Creek uplands also supports a broad range of wildlife, including threatened and special-status species, such as northern spotted owl (*Strix occidentalis caurina*)and Sonoma tree vole (*Arborimus pomo)*.



Redwood Forest

The forests of the upper watershed make up approximately 50 percent (11,474 acres) of the land cover (GRRCD & PCI 2007). Of this forested land, almost 50 percent (over 5,000 acres) is comprised of coast redwoods (*Sequoia sempervirens*). In mature stands, these large conifers create a dense canopy, and the understory is often sparse. Common understory species include shade-tolerant plants, such as sword fern (*Polystichum munitum*), coastal wood fern (*Dryopteris arguta*) and slim Solomon's seal (*Smilacina stellata*)[3]. In younger, more open stands, other woody species can also be abundant. These include Pacific madrone (*Arbutus meniesii*), hazlenut (*Corylus cornuta*), huckleberry (*Vaccinium ovatum*), poison oak (*Toxicodendron diversilobum*), and wood rose (*Rosa gymnocarpa*).

Logging and clearing for agriculture that began in the early 1800s have reduced and shaped the redwood forests of the watershed today. Redwood from the area was used

[3] Botanical names and distribution information based on Best et al. 1996 and Lamont 2004.

for construction in San Francisco during the Gold Rush and for rebuilding efforts after the earthquake of 1906. Timber production declined in the 1920s as old-growth redwoods were depleted. Intensive residential and agricultural development began in the 1940s, and logging intensified again.

By 2000, most of the headwaters of Salmon Creek had been logged. However, the watershed still supports healthy stands of second- and third-growth redwoods in moister areas and in the coastal fog belt. According to a 1994 U.S. Forest Service analysis, trees in the medium-large and small-medium size classes (12-30" diameter at breast height) are most abundant. A few pockets of old-growth redwood forest remain in the watershed, including the Grove of the Old Trees located on a ridgetop above Occidental, which was protected by conservation easement in the 1990s. Sonoma Land Trust and the Sonoma County Agricultural Preservation and Open Space District hold numerous other easements in the watershed, particularly along Coleman Valley Road. Approximately 4 percent (800 acres) of the watershed is in use for timber production today (GRRCD & PCI 2007).

Mixed Evergreen Woodland

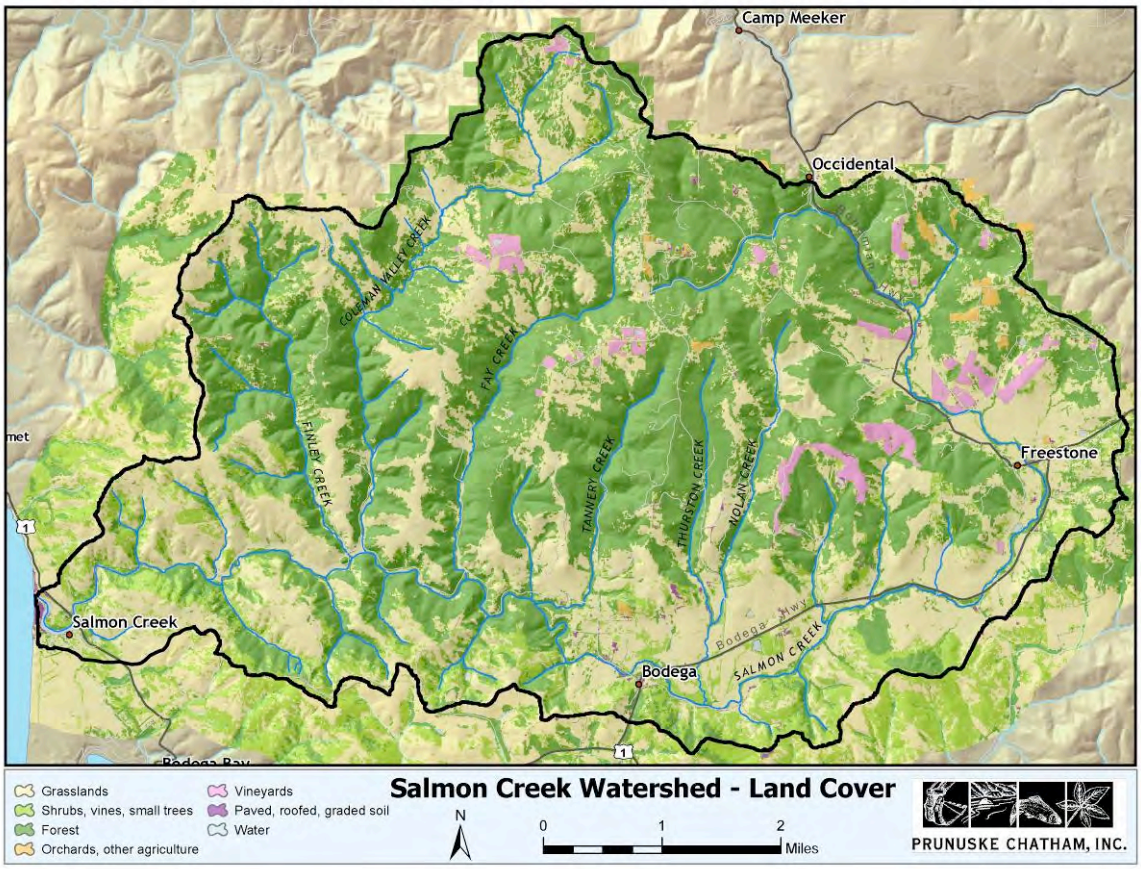
A mixture of evergreen trees makes up the remainder of forest (over 6,000 acres) in the watershed. This includes forests where Douglas-fir (*Pseudotsuga menziesii*) dominates, as well as mixed woodlands of coast live oak (*Quercus agrifolia*), Douglas-fir, California bay (*Umbellularia californica*), tanoak (*Lithocarpus densiflora*), madrone (*Arbutus menziesii*), and buckeye (*Aesculus californica*). Like the redwood forest, many of these lands have been logged or cleared, and now support younger forests or have been converted to annual grassland.

Google Earth via USFS Aerial Detection Survey, Sonoma County 2007 Tree Mortality

Woodlands of the watershed have also been altered by other processes. Sudden Oak Death, a forest disease caused by the pathogen *Phytophthora ramorum*, has infected California bays and killed tanoaks and coast live oaks in the watershed (UC Berkeley 2010). Aerial surveys of the county show many dead or dying tanoaks in the central portion of the watershed in the hills southwest of Occidental (USFS 2009). In affected areas, the density of dying trees ranges from 1 to 10 per acre. (Laboratory testing has not been done to confirm *P. ramorum* as the cause of all these die-offs, but it is considered to be the most likely cause (USFS 2009; Bell 2010). Where infection occurs, the abundance of dead and dying trees increases the risk of wildfire. Near roads, structures, and populated areas, the risks of damage or injury from falling trees is also increased.

Fire suppression in the watershed and in the region may also be changing forest composition (Hastings et al. 1997). Prior to European-American settlement, Native Americans used fire in many settings to increase habitat for the oak woodland and grassland species most useful to them. Since European settlement, the frequency of low-intensity fires has been reduced. As a result, fire-sensitive Douglas-fir is increasing in abundance, shading out smaller-statured oaks and other hardwoods.

Figure 3. Salmon Creek Watershed land cover map.



Special-status plant species documented in the mixed evergreen woodland of the watershed include western leatherwood *(Dirca occidentalis*) and Napa false indigo (*Amorpha californica* var. *napensis*) [both considered to be fairly endangered in California by the California Native Plant Society (CNPS)]. Western leatherwood is a deciduous shrub with very flexible wood. It is endemic to the San Francisco Bay region and occurs on moist wooded slopes. Napa false indigo is a shrub in the pea family known only from Marin, Monterey, Napa, and Sonoma counties. Both species are threatened by habitat loss from agricultural and residential development.

Photo courtesy of Gerald and Buff Corsi © Calif. Academy of Sciences

Special-status animal species documented in the forests and woodlands of the watershed include the northern spotted owl and Sonoma tree vole. The northern spotted owl *(Strix occidentalis caurina)* is federally listed as threatened and is a California Species of Special Concern. It is a nocturnal species that requires dense, multi-layered canopy cover for roosting sites – predominately occurring in forested habitats; however, occasionally they are observed in riparian woodlands along Salmon Creek (Fawcett 2010). Spotted owls feed upon a variety of small mammals (including dusky-footed woodrats), birds, and large arthropods. Nest sites include tree or snag cavities or broken tops of large trees. A pair of owls may use the same breeding site for 5 to 10 years; however, they may not breed every year. The spotted owl has experienced a population decline due to the loss and degradation of existing mature and old-growth forests.

The Sonoma tree vole *(Arborimus pomo)* is listed as a California Species of Special Concern by CDFG. This rodent occurs only in the coastal fog belt from the Oregon border to Sonoma County in Douglas-fir, redwood, and mixed evergreen forests. It feeds almost exclusively on Douglas-fir needles and prefers to build its nests in tall trees or the broken tops of younger trees. Its home range generally consists of one to several Douglas-fir trees. Nests are typically constructed from 6 to 150 feet above ground and are made primarily of resin ducts from Douglas-fir needles, which they remove before eating. The primary predators of Sonoma red tree vole are spotted owls, saw-whet owls, and possibly raccoons.

Grasslands

Grasslands in the watershed include native-dominated coastal prairie and serpentine grassland, as well as annual grassland dominated by European annual grasses. Together, these types comprise 37 percent of the land cover (over 8,000 acres).

Coastal prairie occurs primarily in areas that have not been heavily disturbed by human uses, on slopes and ridges near the influence of the ocean in the southwestern portion of the watershed. Perennial bunchgrasses, bulbs, and other native herbs characterize these habitats. Typical species in the Salmon Creek Watershed include purple needlegrass (*Nassella pulchra*), California oatgrass (*Danthonia californica*), lupine (*Lupinus* spp.), brodiaea (*Brodiaea* spp.), clarkia (*Clarkia* spp.), and Douglas iris (*Iris douglasiana*).

Native grasses also dominate grassland habitats where serpentine soil is present. Serpentine soils have unusual levels of some minerals important to plant survival and growth; as a result, serpentine plant communities are often unusually rich in native and endemic species. In the Salmon Creek Watershed, serpentine grassland occurs in patches along two bands of serpentine-derived soil in the northern part of the watershed. Typical species include Idaho fescue (*Festuca idahoensis*), woodland brome (*Bromus laevipes*), woolly sunflower (*Eriophyllum lanatum*), and buckwheat (*Eriogonum* spp.).

A fenceline separates grassland grazed by livestock (lower right) from ungrazed grassland (upper left).

Annual grassland occurs in more disturbed and intensively used areas, including many ranchlands. Annual grasslands, dominated by nonnative species, are abundant in the southern part of the watershed. European annual grasses were introduced to California in the 1800s. The historic introduction of European grasses to California, coupled with disturbances such as intensive livestock grazing and clearing, have led to conversion of native grassland to annual grassland. Typical species in the Salmon Creek Watershed include wild oats (*Avena* spp.), ripgut brome (*Bromus diandrus*), ryegrass (*Lolium multiflorum*), and velvetgrass (*Holcus lanatus*). Common forbs found in these grasslands include nonnative filaree (*Erodium* spp.), cut-leaf geranium (*Geranium dissectum*), bur-clover (*Medicago polymorpha*), vetch (*Vicia* spp.), and clovers (*Trifolium* spp.).

Local researchers are investigating management strategies to maintain and restore native grassland species (Ocean Song 2007). Prescribed burning and managed livestock grazing are two of the main tools thought to be effective in coastal grassland settings. However, relationships between managed disturbance and plant communities are complex, and outcomes vary with plant species, timing of disturbance, climate, and many other factors. Research continues to clarify how local land managers can use grazing and burning effectively.

Sensitive plant species documented in the grasslands of the watershed include showy Indian clover *(Trifolium amoenum)* (federally listed as endangered) and seaside tarplant (*Hemizonia congesta ssp. congesta*) (considered by CNPS to be fairly threatened in California). Showy Indian clover, thought to be extinct until a discovery of a single plant in 1993, is now known only from one remnant population in Marin County. Researchers are investigating the possibility of reintroducing the species to former habitat. Both showy Indian clover and seaside tarplant occur in areas of mixed native and nonnative grassland. The primary threat to their survival is habitat loss due to agricultural and residential development (CNPS 2010). A number of other species were documented historically in the watershed but have not been recently observed: purple-stemmed checkerbloom (*Sidalcea malviflora* ssp. *purpurea*), perennial goldfields (*Lasthenia californica* ssp. *macrantha*), and yellow larkspur (*Delphinium luteum).* In addition to habitat loss, competition from nonnative plants, road construction, livestock grazing, and possibly trail construction are other likely factors in the decline of these rare plants.

Focal special-status animal species occurring in the grasslands include the burrowing owl, American badger, and Myrtle's silverspot butterfly:

The **burrowing owl (*Athene cunicularia*)** is a California Species of Special Concern. It is a subterranean nester, dependent upon burrowing mammals for its underground home. In the Salmon Creek Watershed, the burrowing owl has been documented in coastal terrace prairie with a mosaic of native and nonnative grasses and forbs. This species is primarily an uncommon winter resident, as it no longer breeds in Sonoma County. Threats to this species are habitat loss due to agricultural and urban development and habitat degradation due to reductions of burrowing mammal populations.

Photo courtesy of Joyce Gross.

Gerald and Buff Corsi © Calif. Academy of Sciences

The **American badger (*Taxidea taxus*),** a California Species of Special Concern, occurs in a variety of habitat types with dry, friable soils. This carnivorous species consumes primarily fossorial rodents but will also eat reptiles, amphibians, insects, eggs, birds, and carrion. Badgers are territorial throughout the year with size of the territory dependent on the availability of food. Typical territory size is approximately 3 or 4 square miles. Territories can be shared. Badgers dig their own burrows which are often quite extensive. They are active year-round, although less active in winter. Mating occurs in summer and early fall with young (average 2 to 3) born in early spring. Badgers can tolerate some level of human activity. Potential threats to badgers in the watershed include ground-disturbing development, pets roaming free, and barbed wire fencing (CDFG 2010). Within the watershed, badgers are noted near the Chanslor Ranch and low coastal hills and in and around Bodega Creek (Fawcett 2010).

Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*), federally listed as threatened, may also occur in the watershed. Historically widespread in coastal areas from the Russian River south to San Mateo County, this species is now known only from four populations in Marin and Sonoma counties. This brown-to-orange butterfly lives in coastal dunes, scrub, and prairie, within 3 miles of the coast. It generally prefers sites at less than 1,000 feet elevation, sheltered from the wind and within the fog zone, which provide a large numbers of adult nectar plants. Adult Myrtle's silverspots nectar on a number of species including, but not limited to, gum plant (*Grindelia rubicaulis*), yellow sand verbena (*Abronia latifolia*), mints (*Monardella* ssp.), seaside daisy (*Erigeron glaucus*), and nonnative bull thistle (*Cirsium vulgare*) and false dandelion (*Hypochaeris radicata).* Females lay eggs singly on western dog violet (*Viola adunca*), and the entire reproductive cycle is dependent on this species (USFWS 1998).

Coastal Scrub and Chaparral

Coastal scrub occurs along the slopes of the southern part of the watershed, typically within reach of ocean winds and salt spray. Approximately 2,000 acres of coastal scrub are found in the watershed today (approximately 8 percent of the land cover). Dominant plants include shrubs, such as coyote brush (*Baccharis pilularis*), poison oak (*Toxicodendron diversilobum*), and elderberry (*Sambucus nigra* ssp. *caerulea*), as well as sword fern (*Polystichum munitum*), bracken fern (*Pteridium aquilinum*), and rushes (*Juncus* spp.) and sedges (*Carex* spp.). Coastal scrub often intergrades with annual grassland or coastal prairie. In some locations, the extent of coastal scrub may have decreased since pre-European settlement, as clearing and livestock grazing have caused a transition to

grassland. In other locations, coastal scrub acreage may have increased as modern fire suppression replaced Native American burning practices.

Sensitive plant species documented historically in the coastal scrub of the watershed include Baker's larkspur (*Delphinium bakeri*, federally and state listed as endangered) and coastal bluff morning-glory (*Calystegia purpurata* ssp. *saxicola;* CNPS List 1B.2, fairly endangered in California). Baker's larkspur, once known from Coleman Valley, is now known from only one remnant population in northern Marin County. Threats to the species include agricultural conversion, road maintenance, and grazing. The Coleman Valley area is now designated as a portion of the critical habitat for Baker's larkspur where it may be reintroduced (USFWS 2003). Coastal bluff morning-glory is known from coastal scrub and dunes of Marin, Sonoma, and Mendocino counties. It is threatened by development, foot traffic, and nonnative plants. There are no special-status animals specific to coastal scrub and chaparral.

Invasive Species

Many nonnative, invasive species are abundant in the uplands of Salmon Creek Watershed. Three are particularly damaging to local habitat, directly competing with native species and also altering ecosystem processes. All three of these species are yellow-flowering, evergreen shrubs in the pea family, apparently intentionally

introduced from Europe: gorse (*Ulex europaeus*), French broom (*Genista monspessulana*), and Scotch broom (*Cytisus scoparius*). All of these species can fix atmospheric nitrogen, helping them colonize nitrogen-poor soils and outcompete native plants. They are also unpalatable and/or toxic to livestock, so their infestations reduce rangeland quality as well as native habitat. All three species produce abundant, long-lived seed, so eradication efforts must be long-term undertakings.

Gorse is a prickly shrub that forms dense, nearly impenetrable thickets on some hillsides of the watershed. Gorse tends to spread slowly, with seeds too heavy to be dispersed by wind but potentially carried by ants, quail, and humans. Gorse is highly flammable and can pose a significant fire hazard (California Invasive Plant Council 2010).

French broom and Scotch broom are both abundant along the roadsides of the watershed and in other disturbed habitats. Pods of broom open explosively, dispersing seeds several yards away. Seeds are dispersed further by ants, birds, flowing water, and road maintenance machinery. Broom is flammable and, in wooded areas, can carry fire to the tree canopy layer, increasing fire intensity.

Other invasive species in the watershed that are known to invade native habitat include pampas grass (*Cortaderia* spp.), English ivy (*Hedera helix*), forget-me-not (*Myosotis discolor*), Himalayan blackberry (*Rubus discolor*), giant reed (*Arundo donax*), cape ivy (*Senecio mikanioides*), and periwinkle (*Vinca major*).

Preventing the spread of invasive plants, and quickly eradicating small new infestations, are crucial to managing these and other species. Once established, control is usually costly and difficult. Carefully managed prescribed burning, manual removal, and goat grazing have all been used successfully to control gorse and broom in other areas.

Streams

Salmon Creek and its tributaries flow through steep terrain in their headwaters onto the gentle slopes of the southern watershed and enter the Pacific Ocean north of Bodega Bay. Many of the upper watershed tributaries remain forested with complex communities of redwoods, firs, oaks, and bays shading the streams and stabilizing creek banks. In the lower reaches, riparian corridors continue but are often narrowed and less diverse.

Historic land-use practices in the watershed have contributed to impaired riparian-zone habitat conditions and chronic, widespread disturbances that have altered channel processes (PCI 2006, Appendix A). In the late 1800s and early 1900s, riparian clearing for tilled agriculture and upland logging practices that used the streambed as a haul road, notably in Fay and Tannery Creeks, further simplified, deepened, and widened the channels. More extensive and technologically advanced logging and a couple of large, upland fires in the mid-1900s generated large sediment loads that are still traveling through the system. Additionally, throughout the mid-1950s to 1980s, channel clearing activities by the Sonoma County Water Agency, CDFG, and local landowners removed all large wood, kept riparian vegetation trimmed, and maintained a simplified channel to maximize flood conveyance.

As a result of channel alteration activities, in many locations channel width and structure are out of equilibrium with the size of the watershed and the historic flow regimes. The combination of incised and artificially widened channels, increased sediment loads, and minimal instream structure from large wood or floodplain development decreases the ability of the channel to develop good instream habitat structure. In fact, in some locations, a bowling-alley effect has been created in which sediment moves in large, unsorted masses during high-flow events, filling pools and depositing fines in spawning riffles. The high, historic sediment loads moving through the system have no areas in which to be stored in the upper and middle reaches of the stream system, as the channels are incised and disconnected from their floodplains. Thus, this sediment is being transported to, and deposited in, the estuary at an unusually high rate.

Agricultural and residential development practices have encroached on the channels, narrowing the riparian corridor. In some cases, the channel has been hardened to protect infrastructure adjacent to the stream. Water supply extractions in the uplands, the alluvial valleys, and instream have decreased the water available for summer dry-season flows (PCI and OAEC, in press). Hardening of land throughout the watershed and stormwater practices designed to move excess water quickly increases flood peaks and fine sediment delivery, while decreasing the amount of water infiltrated and available as groundwater in the dry season.

Together, this suite of watershed changes has resulted in incised and artificially widened channels and loss of instream habitat diversity. High-flow refugia—areas of slower-velocity water where fish can shelter during storm events—are limited because of an insufficient quantity of large wood, few undercut banks, and disconnection of the stream channel from its floodplain. Pool frequency and depth are also below desired conditions for salmonid-bearing streams. (See Chapter 4 and Appendix A.)

In 2001 through 2003, CDFG completed stream habitat and biological inventories on mainstem Salmon Creek and the tributaries of Coleman Valley, Finley, Nolan, Tannery, and Thurston Creeks (CDFG 2003a-b; 2004a-e). The inventories were conducted to assess the quantity and condition of aquatic habitat, with an emphasis on salmonid habitat, and document the presence and distribution of aquatic species. The results of the stream inventories found a low number of deep pools, low instream shelter values in pools, and gravels/cobbles embedded with fine sediment within the mainstem and all tributaries surveyed.

Despite changes in the watershed and their subsequent effects on Salmon Creek and its tributaries, the stream channels still support a variety of native fish and wildlife communities. Particularly noteworthy are the presence of anadromous salmonids, including native runs of steelhead and reintroduced coho salmon, and sensitive wildlife species, such as the California red-legged frog (*Rana draytonii)*, western pond turtle (*Actinemys marmorata)*, and California freshwater shrimp (*Syncaris pacifica)*.

Salmonids

Steelhead trout (*Oncorhynchus mykiss)* and coho salmon (*O. kisutch*) are anadromous fish; they spawn in freshwater and mature in the ocean. Salmon Creek steelhead are part of the central California coast Distinct Population Segment (DPS), which is federally listed as threatened by NOAA's National Marine Fisheries Service. Coho salmon, central California coast ESU (Evolutionary Significant Unit), are both federally and State-listed as endangered.

Steelhead trout and coho salmon were once abundant in Salmon Creek and its tributaries. Tales of their numbers, sizes, and favorite pools are still a vital part of the local history and lore; see *Historical Timeline of Salmon Creek Watershed* in PCI 2006. Dating back to the early 1920s, local sportsmen called for blasting the bedrock falls on mainstem Salmon Creek, now part of Salmon Creek School, to allow fish passage. Throughout the 1950s, fish appeared relatively abundant in the watershed. A record from 1953 noted 20 anglers caught 13 silver salmon (coho salmon) in a period of 39 hours, all ranging in size from 2.5 to 10 pounds.

In 1961, the first stream survey of Salmon Creek was conducted by CDFG noting the presence of both adult steelhead and coho salmon. Stream surveys were also conducted in 1964 and 1965. In the 1964 survey, the majority of fish observed were silver salmon, 50 to 100 fish per 100 feet with similar findings in 1965—85 silver salmon and 64 steelhead fingerlings were caught. During a survey in 1970, 25 to 40 fish per 100 feet were noted. In 1974, there was a record salmon catch at sea off Salmon Creek. Up to the 1970s, fishermen annually broke through the

Adult coho released into Salmon Creek, December 2008.

sandbar at the estuary noting coho salmon just "rushed in" and always made it to the plate in time for Thanksgiving.

Now only a small population of steelhead continues to return each year, and the last naturally propagated coho was seen in 1996 (Cox 2005). Many residents, community groups, and agencies have come together to understand reasons for the decline and attempt to restore the fisheries. These efforts include restoring the key habitat features to support each lifestage of these migratory species. Approximately 500 adult coho salmon were reintroduced into the creek in December 2008 and 2009 as part of the California Department of Fish and Game's annual coho broodstock program. The fish were selected from two strains from neighboring watersheds in an attempt to recreate the likely genetic composition of the historic fishery.

Coho salmon and steelhead trout lifecycles

Adult steelhead trout migrate upstream from the ocean during the rainy season, anytime from November to March. They enter the stream only when sufficient flow has opened the coastal lagoon. Steelhead spawn (mate and lay eggs) typically at the downstream edge of pools where cover habitat exists nearby for predator protection. Eggs are laid in a redd, a depression dug into cobble or gravel substrate. Unlike salmon, steelhead can migrate out to the ocean after spawning and return in subsequent years to spawn again. Eggs hatch in 30-60 days, depending on stream temperatures. The newly hatched fish—called alevins—stay in the gravel for a few additional weeks until their yolk sac is absorbed. When they emerge, they seek slow-water areas, often at the stream margins. As they grow bigger, the juvenile fish move into faster water to feed on drifting insects.

Juvenile steelhead remain in freshwater streams from 1 to 3 years or longer. Rearing juveniles have many habitat requirements. Most important, they need sufficient, cool streamflow to transport drifting insects for feeding and cover habitat, such as undercut banks, woody material, boulders, and deep pools, to hide from predators and areas for refuge during high flows. When juveniles are large enough, they migrate out to the ocean as smolts. During out-migration, steelhead and salmon need adequate streamflow to swim past barriers and cover for predator protection.

Coho salmon have a similar, but more rigid, lifecycle than steelhead. They spend their first year in freshwater streams, migrate out to sea where they mature for two years, and return to their native creeks to spawn and die. Because all non-hatchery females are three years old, coho salmon develop three consecutive "year classes" in each stream; survival of one year class affects subsequent spawning three years later. Coho salmon are vulnerable to extreme environmental conditions, such as droughts, floods, and the timing of winter storms, which affect when the sandbar opens for upstream migration and influence survival of redds and juveniles.

Hines (2010) completed a detailed analysis of coho salmon limiting factors based on the findings of the CDFG inventories, some field observations, and anecdotal information on the watershed. Habitat indicators by lifestages were rated to determine those factors limiting the production of coho salmon within the watershed. Those with the poorest ratings included low base flows, primary pools, and shelter ratings during the summer rearing period; lack of complex, off channel habitat during winter rearing; poor habitat

availability for estuary rearing smolts; and lack of large wood debris and high turbidity levels for multiple life stages.

Other Sensitive Aquatic Species

In addition to supporting native fish populations, Salmon Creek and its tributaries provide critical habitat for other special-status aquatic species. Particularly noteworthy are the presence of California red-legged frog, California freshwater shrimp, and northwestern pond turtle.

Photo courtesy of Jennifer Michaud (PCI)

California red-legged frog *(Rana draytonii)* is federally listed as threatened and a California Species of Special Concern. In general, they are most common in marshes, streams, lakes, reservoirs, ponds, and other water sources with plant cover. Breeding occurs in deep, slow-moving waters with dense shrubby or emergent vegetation from late November through April. Egg masses are attached to emergent vegetation (e.g., *Typha* sp. or *Scirpus* sp.) near the water's surface. Tadpoles require 3.5 to 7 months to attain metamorphosis. Adults take invertebrates and small vertebrates. Larvae are thought to be algal grazers. Within the watershed, California red-legged frogs are known to occur within stream channel habitats from the estuary and further upstream near the town of Bodega and tributaries. Reservoirs, wetlands, and other large perennial water sources also support this species; however, reported observations in these areas are spotty.

Photo courtesy of Bill Cox

California freshwater shrimp *(Syncaris pacifica)* is federally and State-listed as endangered. It is a small, 10-legged crustacean occurring in low-elevation and gradient (less than 1%) perennial streams in Marin, Sonoma, and Napa counties. They occur in shallow pools away from the main current where they feed primarily on detritus and, to a lesser extent, on decomposing vegetation, dead fish, and invertebrates. Most shrimp appear opaque to nearly transparent with colored flecks across their bodies. Females can appear dark brown to purple under certain conditions. Breeding occurs in the autumn, but young do not hatch until the following May or early June. After breeding, female shrimp carry the fertilized eggs attached to their abdominal swimming legs throughout the winter. The freshwater shrimp has been extirpated from many streams and continues to be threatened by introduced predators, pollution, and habitat loss. Within the watershed, freshwater shrimp are known to occur from the upper end of the estuary to just north of Freestone along the mainstem (CDFG 2010). Population numbers within the watershed have tended to fluctuate from year to year due to pollution and drought (CDFG 2010).

The **northwestern pond turtle *(Actinemys marmorata marmorata)*** is a California Species of Special Concern and is one of two distinct subspecies of the western pond turtle. They are most commonly found in or near permanent or semi-permanent water sources in a variety of suitable habitats throughout much of western California. This omnivorous species requires basking sites, such as emergent logs, rocks, mud banks, or mats of aquatic vegetation, for thermoregulation. Underwater retreats are also required for predator avoidance. Nesting sites of this species have been found some distance, up to 400 meters or more, from aquatic habitat. They have also been found using upland sites for aestivation and overwintering. Within the watershed, pond turtles occur along stream channel habitats and also utilize reservoirs and other permanent water sources extensively.

Photo courtesy of Jennifer Michaud (PCI)

Riparian and Wetland Plant Communities

Upper reaches of the watershed's streams are cloaked in forests of redwood, Douglas-fir, oaks, bays, and tanoaks. While logging and clearing have occurred in these areas, the streams remain generally well-shaded by second-growth trees. Lower in the watershed, red alders *(Alnus rubra)*, big-leaf maples *(Acer macrophyllum)*, and buckeyes *(Aesculus californica)* line the streams. Understory shrubs and vines, including Pacific ninebark *(Physocarpus capitatus)*, snowberry *(Symphoricarpos* spp.), gooseberry *(Ribes* spp.), California blackberry *(Rubus ursinus),* and honeysuckle *(Lonicera hispidula)*, add to the structural complexity of the riparian forest and provide food and shelter for wildlife. The complex root structures of this varied vegetation holds soil in place, protecting streambanks and water quality. In the gentle terrain of the southern watershed, where agricultural uses are more extensive, the riparian corridor narrows. Willows *(Salix* spp.) dominate many stretches. Occasional larger trees, including coast live oaks, buckeyes, and alders, also occur.

Patches of seasonal wetland occur in low areas near Salmon Creek. Typical plants found in these areas include common rush (*Juncus patens*), meadow barley (*Hordeum brachyantherum*), and spikerush (*Eleocharis macrostachya*). Historically, wetland habitat along the middle reach of Salmon Creek supported a number of rare plant species, including federally endangered Sonoma alopecurus *(Alopecurus aequalis* var. *sonomensis)*, as well as saline clover *(Trifolium depauperatum* var. *hydrophilum)*, bristly sedge *(Carex comosa)*, and swamp harebell *(Campanula californica)*. With agricultural and residential

development, marsh habitat has declined, and none of these species has been documented in recent times.

Estuary

Aerial photograph of the Salmon Creek Estuary
Photo taken on January 28, 2008 by Lauren Hammack (Prunuske Chatham, Inc.)

In the lower portion of Salmon Creek, the stream's freshwater meets and mixes with saline tidewater, to create a coastal estuary extending approximately 1.3 miles inland. The estuary supports vital habitat for many coastal and marine organisms by providing essential food, cover, migratory corridors, and breeding/nursery areas. The brackish water of the estuary also provides habitat for returning adult salmonids and outmigrating smolts as they undergo the physiological changes necessary for transition from freshwater to saltwater and back again. The lower estuary is part of Sonoma Coast State Beach and is managed by State Parks. As in most small Northern California streams, the mouth of the estuary is closed by a sandbar in spring or summer every year and remains closed until after the first significant storms. Under conditions of adequate streamflow, the closed estuary converts to a largely freshwater lagoon during the summer months.

Coastal Brackish Marsh and Dune Plant Communities

Coastal brackish marsh vegetation occurs near the mouth of the estuary. These low-growing plants thrive in the accumulated sediments of the estuary and are adapted to fluctuating water and salinity levels. Typical species include jaumea (*Jaumea carnosa)*, saltgrass (*Distichlis spicata*), rushes (*Juncus* spp.), and bulrushes (*Scirpus* spp.).

A limited area of dune habitat occurs near the mouth. Plants and wildlife that inhabit native dune habitat are adapted to the shifting sandy substrate and constant exposure to wind and salt spray. Vegetation is typically sparse, composed mostly of low-growing herbs such as beach sand-verbena (*Abronia umbellata*), sea rocket (*Cakile maritima*), beach strawberry (*Fragaria chiloensis*), with occasional shrubs such as coyote brush (*Baccharis pilularis*). In Salmon Creek Watershed and along much of California's coast, dune habitat has been altered by the introduction of European beachgrass (*Ammophila arenaria*). This large perennial bunching grass was introduced to stabilize shifting dunes, and it is effective at doing so. However, it also reduces habitat for native species adapted to natural dune dynamics. Many land managers in coastal California are working to remove beachgrass and restore native dune species.

Sensitive plant species documented historically in the coastal dunes of the watershed include Blasdale's bentgrass (*Agrostis blasdalei*; CNPS List 1B.2, fairly threatened in California) and blue coast gilia (*Gilia capitata* ssp. *chamissonis*; CNPS List 1B.1, seriously threatened in California). However, these species have not been observed in recent decades.

Species Usage and Habitat Conditions

Adult salmonids use estuaries for staging in preparation for their upstream migration. Juveniles use them for rearing and for completing the physiological adjustment from fresh to salt water that will allow them to live in the ocean. Juveniles may linger in the estuary for weeks and may move in and out several times before remaining in the ocean. Adequate flow, good water quality, sufficient cover, habitat complexity, and invertebrate food sources within the estuary are all very important factors for the survival of anadromous fish.

Existing biotic conditions of the Salmon Creek estuary were characterized as part of the *Salmon Creek Estuary Study Results and Enhancement Recommendations* (Estuary Study; PCI 2006). Monthly biota was sampled over a one-year period providing a snapshot of salmonid usage and limiting factors with the estuary and occurrence of other coastal species. Water quality, hydrologic, and geomorphic conditions were also assessed to determine how the estuary currently supports and is utilized by salmonids.

Ten species of fish were collected (by trawl and seine) during the Estuary Study (PCI 2006). Steelhead were the only anadromous species captured. The largest number of steelhead captured was 400 individuals of varying age classes on September 8, 2004. Additional sampling by seine yielded 1, 2, 2, 1, and 7 individuals during surveys conducted in July, August, October, November, and March, respectively. Other fish species documented in the estuary included tidewater goby, prickly sculpin, Pacific staghorn sculpin, cabezon, starry flounder, Pacific herring, shiner perch, and topsmelt, as well as a variety of invertebrates, including bay shrimp, black-tailed shrimp, and opossum shrimp.

The study found that many juvenile steelhead (likely in the thousands) migrate from upstream to the Salmon Creek estuary in the late summer/early fall and congregate near the mouth where the water remains mixed and cool. This large complement of the watershed's annual salmonid production becomes trapped in the shallow, open area as flows upstream drop, and water quality becomes inhospitable in other areas of the estuary. Predation by pelagic birds significantly reduces fish populations in this critical habitat, with up to 100% predation occurring during drought years.

The study also found that increased water consumption in the upper watershed from groundwater and direct stream withdrawals has reduced base streamflows during critical periods. Low spring and summer flows increase pool stratification in the estuary to create bottom saline layers too hot and low in oxygen to sustain salmonids. Fish are confined to the upper freshwater layer and to the well-mixed area near the sandbar where they are vulnerable to predation by birds. Low spring and summer flows also reduce lagoon elevations and delay the breaching of the sandbar. If the sandbar opens after or near the end of the coho upstream migration period, as occurred in the 2004/2005 winter, coho have little, if any, chance of returning to Salmon Creek. Low summer flows also reduce viable salmonid rearing habitat in the main channel and tributaries. Many juvenile salmonids are stranded as pools go dry and with no surface or subsurface flow, the remaining pools become anoxic.

Changes in the delivery of coarse sediment have also altered the estuary, compromising habitat for salmonids and other aquatic species. Significant amounts of coarse sediment have dramatically decreased the areal extent and depth of the estuary since the mid 1800s. Ongoing deposition is occurring at a rapid rate. For example, a 2-year period

between 2004 and 2006, over 2 feet of sediment was deposited upstream and downstream of the Highway 1 bridge. Summer lagoon depths now range from 2 to 6 feet as compared to 6 to 12 feet in the 1950s and 1960s. Erosion of fine sediments from the upper watershed creates high turbidity levels that impair salmonid physiological functioning and behavior.

In addition to supporting salmonids, the lower Salmon Creek estuary provides habitat for two other noteworthy special-status species, tidewater goby and western snowy plover:

The **tidewater goby (*Eucyclogobius newberryi*)** is federally listed as endangered and a California Species of Special Concern. It is a small, elongate, grey-brown fish endemic to coastal lagoons, estuaries, and marshes of California. Its annual lifecycle is closely tied to the dynamics of lagoons and estuaries with breeding commencing after their habitat closes to the ocean. Small vertical nesting burrows are dug in the substrate in areas of coarse sand with peak breeding activity occurring in late April through early May. Threats to tidewater goby include development, water diversion and manipulation of habitat, channelization, nonpoint and point source pollution, discharge of agricultural and sewage effluents, and impacts from cattle grazing. The Salmon Creek estuary supports a robust population of gobies.

The **western snowy plover (*Charadrius alexandrinus nivosus*),** federally listed as threatened and a California Species of Special Concern, is a small shorebird, approximately 6-inches in length. They breed primarily on coastal dunes and beaches, including beaches at creek and river mouths, and salt pans at lagoons and estuaries. They forage for small invertebrates amongst beach sand, kelp, and low vegetation. The spread of the densely growing European beachgrass has reduced habitat for the snowy plover. Other threats to plover populations include disturbance by humans and pets. On-going surveys by State Parks have documented plovers occupying the lower estuary during the non-breeding season (Dekelaita and O'Neil 2007). One nesting attempt was successful in 2005; however, this was attributed to the unusual configuration of the mouth of Salmon Creek at the time. For the most part, this species is thought to be an uncommon winter resident.

Photo courtesy of Dee E. Warenycia.

Climate Change

Average temperature in California has risen 1.5° F over the past 50 years and is projected to rise another 2-4° F by the end of the century (Karl et al. 2009). In California, precipitation is likely to decline slightly overall but with more intense storms during a shorter rainy period and a longer, hotter dry season, resulting in both more droughts and more floods (Karl 2009). Battin et al. (2007) found the three most important climate-induced hydrologic changes for salmonids are peak flow during egg incubation, stream temperature during pre-spawning, and minimum flow during spawning. Scour from high flows during incubation is a significant negative impact for winter-run species (Bisson 2008). Lower flows in the summer will reduce pool depth and riffle connectivity while higher water temperatures will likely promote algal growth and lower dissolved oxygen. These changes, in turn, reduce the quantity of preferred insect food sources even as warmer water raises fish metabolism and food demand.

Climate change will also impact the health and composition of watershed vegetation. Protection and enhancement of riparian habitats can play a vital role in helping aquatic and terrestrial organisms adapt to climate change (Seavey et al. 2009). Because of their high water content, riparian forests absorb heat and can protect both plants and animals from extreme temperatures (Naiman et al. 2000) while providing connectivity to different microclimates.

CHAPTER 3: UPLANDS MANAGEMENT ACTION PLAN

Context

Upland habitats in the Salmon Creek Watershed—steep, forested ridges; open, rolling grasslands; and coastal scrub—provide key ecological functions that protect soil, air, and water quality, as well as water quantity. Native plants associated with these habitats evolved under the specific environmental conditions of the region and often have unique adaptations necessary to provide these functions. Many species of animals are dependent upon the upland habitats and associated native vegetation communities. (See Figure 3 for a map of watershed vegetation.)

Looking out from Ocean Song Farm and Wilderness Center. Photo courtesy of Kathleen Kraft.

Complex interactions between soils, climate, vegetation, and water, with variations of topography in the mix, drive the natural processes that determine the quantity and quality of water in the streams, as well as habitat conditions for aquatic and terrestrial animals. Multi-storied forest canopies and well-managed grasslands intercept rainfall, softening its erosive impact on the soil below, slowing water flowing over the ground surface, and promoting infiltration and groundwater recharge. Plant litter on the ground increases this effect. The root systems of trees, shrubs, and grasses stabilize the land, keep the soils in place, and provide pathways for rainwater to travel deep into the ground. Natural disturbance regimes, such as fire, drought, and disease outbreaks, play an important role in maintaining habitat diversity. Research indicates that biodiverse systems composed of native species are more resilient and can recover more quickly from such disturbances than simplified systems, such as monocultures or those composed primarily of nonnative species (Walker 1992, Tilman et al. 1998).

An example of the interdependency of natural processes and habitat in the Salmon Creek Watershed is found in redwood forests. Regeneration of redwoods and their understory counterparts depends on the microclimate that mature redwoods create. The many fine needles of redwoods intercept and condense fog, which then drops to the ground to substantially increase the water available to the redwoods themselves and the tree seedlings, shrubs, ferns, fungi, and soil around them (Dawson 1998). When large patches of redwood forest are cleared, as occurred throughout the Salmon Creek Watershed beginning in the mid 1800s, this process of moisture capture and fog drip is diminished. In turn, groundwater recharge is reduced, which ultimately affects summer baseflow in nearby streams.

In this watershed and throughout California, the annual grasses and livestock practices brought to the region by early settlers have contributed to the conversion of native perennial grasslands to simplified communities of nonnative annual grasses (Stromberg et al. 2007). The perennial grasses native to the Salmon Creek Watershed typically have large root systems to access limited water in the soil during the dry summers and, therefore, have tremendous potential to hold soil and buffer erosive forces. The short-

Native California oatgrass (Danthonia californica) along Coleman Valley Road. Photo courtesy of Kathleen Kraft

lived annual grasses with their shallow roots are not as effective at trapping and holding moisture, preventing erosion, or storing biomass.

Both forests and grasslands serve a major role in carbon storage and nutrient cycling. Inappropriate clearing of forests and tilling of soils accelerate the release of carbon to the atmosphere and reduce the ongoing carbon sequestration that trees or grasslands would have provided. Nutrients absorbed from the soil are used for plant growth and incorporated into leaves, stems, roots, and seeds. These, in turn, provide essential nutrition for wildlife and livestock. As plants and animals die and decay, nutrients are released back into the soil. Inappropriate logging, clearing for new construction, and some agricultural practices remove nutrients from the watershed.

Although 50% of the watershed is occupied by forests and woodlands, little active management of these lands presently occurs. While most redwood and Douglas-fir in the watershed have been logged at least once in the past, logging activity in modern times is minimal with less than 100 acres cut in the last 10 years. Active forest management can benefit forest and woodlands by reducing fuel loads, increasing fire safety, and improving forest health. Potential products generated from these lands include lumber, fire wood, carbon sequestration, open space, and scenic beauty. Utilizing sustainable methods, these benefits can be utilized and enjoyed while protecting soil stability, water quality, and wildlife habitat.

Fires, whether started by lightning or people, are thought to have significantly shaped the vegetation of coastal California (Lightfoot and Parrish 2009). Native Americans of the region used managed burning for a number of purposes, including as a tool to increase the density and vigor of edible bulbs, grasses, and other valued plants. High fire frequencies tend to favor grassland over woody plant communities. Native American fire regimes likely resulted in a landscape of increased diversity with a patchwork of burned and unburned areas (Lightfoot and Parrish 2009). Today, prescribed fire is rarely used in the watershed and unintentional fires are typically suppressed. As a result, fuel loads have increased. The spread of Sudden Oak Death (SOD) and flammable invasive species, such as gorse, adds to the risk of catastrophic, widespread wildfires.

Changes to upland conditions from land-use practices can have wide-ranging impacts on the health of the land, streams, and ocean and on their ability to support humans and native wildlife. Upland stewardship choices that protect or restore natural processes are key to sustaining biodiversity and well-functioning habitat throughout the watershed. Since most of the watershed's residents live in the uplands, achieving upland enhancement goals will depend on collective positive action on property of all sizes from backyards to ranches.

Goals

- Uplands include the native plant communities historically known from the watershed and support robust populations of native wildlife.

- Upland habitats are resilient and biologically diverse with intact ecological functions.
- Upland ecosystems and their management help maintain high water quality and sufficient water supplies for humans, terrestrial and aquatic species.

Uplands Recommendation 1: Manage forests and woodlands to maintain diversity and ecosystem function.

Scientific Reasoning

Forests and woodlands help to protect the quality of water in the Salmon Creek Watershed. Healthy forests increase stormwater infiltration, stabilize slopes, and slow erosion. Logging and clearing in the watershed have altered the age structure and composition of remaining forests. Today's forests are younger, with more closely spaced trees and a denser, brushy understory. This can create a high fuel load of flammable branches. The spread of SOD is changing forest composition and increasing the risk of high-intensity wildfires (UCCE et al. 2008). Maintaining diverse, self-sustaining redwood and mixed evergreen forests will entail protecting existing healthy stands and addressing risks from fire and disease.

Forests also play a key role in carbon cycling. Mature forests sequester and store large quantities of carbon in plants and soil. Protecting mature forest enhances the watershed's ability to absorb and store carbon, potentially mitigating the effects of climate change.

Action 1a. Provide education and technical support for landowners to manage healthy forests.

Specific actions may include removal of dead or diseased tanoaks and invasive species, replanting with native trees of local origin, thinning unhealthy young trees or crowded stump sprouts, and building swales to increase on-site water capture.

Implementation Measures

- Conduct a watershed workshop or small forest "fair."
- Provide information on websites. Distribute handouts at local events.
- Encourage landowners to develop Forest Improvement Plans that address forest health and sustainability and assist landowners in applying for grants for funding plan preparation.
- Encourage landowners to utilize NRCS EQIP Forestry CAP (Conservation Activity Plan) to help fund development of Forest Improvement Plans by Registered Professional Foresters working in partnership with Cal Fire.
- Encourage landowners to utilize NRCS EQIP to implement Forest Improvement Plans.
- Promote management of existing redwood forest to encourage development of late seral stands.
- Coordinate with local conservation corps to provide low-cost work crews to assist landowners.

Action 1b: Identify priority areas for forest and woodland conservation, including late-successional redwoods that provide habitat for special-status species.

Knowing where important forest and woodland tracts exist, in combination with records of special-status species, will help identify opportunities for conservation through education, landowner agreements, or conservation purchases.

Implementation Measures

- Target high priority areas.

Action 1c: Implement a fuel-load management program in cooperation with Cal Fire.
Management actions may include downed wood removal, thinning of crowded and unhealthy trees, thoughtful understory management, and controlled burns.

Implementation Measures

- Target high priority areas.
- Organize neighborhood meetings with Cal Fire and local fire departments.
- Coordinate with local conservation corps to provide low-cost work crews to assist landowners.
- Assist neighborhoods in organizing and finding funding for chipping programs.

Action 1d: Determine the extent of Sudden Oak Death in the watershed and educate landowners about minimizing spread and managing infected forests.

Implementation Measures

- Coordinate with UCCE to monitor extent of SOD.
- Create outreach materials to educate landowners about how to prevent SOD spread, treat diseased trees, and handle infected wood. Distribute at local events, other watershed workshops, and through websites.
- Develop, publish, and publicize Best Management Practice (BMP) recommendations for private forest and woodland owners.

Uplands Recommendation 2: Protect existing coastal prairie and other grasslands rich in native species and manage for healthy grasslands throughout the watershed.

Scientific Reasoning

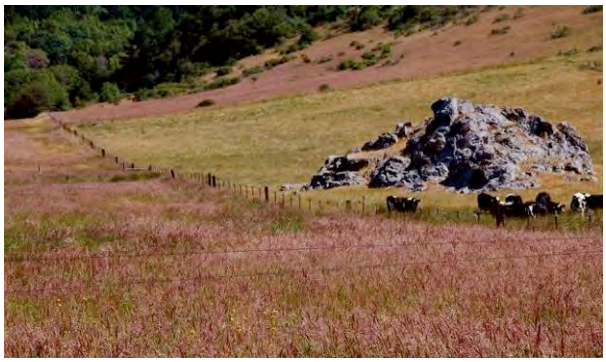
Grasslands in the Salmon Creek Watershed—like grasslands across California—have undergone dramatic changes in the past 200 years. Expanses of native bunchgrass and coastal prairie, rich in native bulbs and annual wildflowers, have been largely replaced by nonnative European grasses. Several native grassland plant species have been extirpated from the watershed, and others are known to be imperiled. Patches of native grassland remain in areas of coastal influence, on serpentine-derived soils, and in other areas of low-nutrient soils within nonnative grassland. However, fire suppression, some livestock grazing practices, and the spread of invasive species are all continuing threats to native grasslands.

Coastal prairie species.
Photo courtesy of Kathleen Kraft

Livestock grazing is a common land use in the Salmon Creek Watershed. Appropriate grazing has the potential to maintain or improve the health of the ecosystem, while high-impact grazing practices can cause severe deterioration of grassland health. Grazing can positively impact rangelands by stimulating plant growth, helping to maintain

optimal leaf area, enhancing nutritive value, removing excess litter, accelerating nutrient cycling, and manipulating botanical composition. In carefully managed conditions, grazing can be used as a control mechanism for invasive and undesirable species. Ecologically based grazing management increases the number of different plant species on rangeland, and creates a mosaic of different habitats that enhance biodiversity. A properly designed grazing system can also be used to provide zones of reduced fine fuel to assist in controlling wildfires.

Protecting and enhancing native grasslands, along with managing annual grassland to increase native species composition, will protect biodiversity and help maintain economically valuable livestock forage. Native perennial bunchgrasses with deep, extensive root systems are very effective at protecting slope stability, an important factor in stream water quality. Healthy grassland also plays an important role in pulling carbon dioxide from the atmosphere and sequestering it in plant tissue and soil.



Velvet grass flourishes in the absence of grazing. Photo courtesy of Jim Colemen

Action 2a: Support watershed ranchers in developing and implementing ranch plans that include sustainable grazing practices.

Implementation Measures

- Coordinate with UCCE and NRCS to support ranchers in developing plans.

Action 2b: Support local research and education efforts to identify and refine management strategies that promote native grassland species.

Implementation Measures

- Establish and support demonstration sites for ongoing education.
- Provide a range of educational materials and tours for ranchers, small grassland owners, and the general public.

Action 2c: Identify priority areas for native grassland conservation.

Action 2d: Develop local seed sources for native grassland plants.

There are very few readily available commercial sources of native grassland seed derived from Salmon Creek Watershed sources. A few commercial sources of California native grassland seed exist, but generally the seed provided is not of local origin. Many native plant populations show local variation. Using local seed ecotypes helps maintain local biodiversity and may also increase the likelihood that planting efforts will be successful. Making local seed available would support landowners and land managers in using appropriate natives in restoration efforts.

Implementation Measures

- Develop database of locations where key grassland species for restoration occur, and where landowners are willing to allow seed collection.
- Offer workshops identifying key grassland species for restoration use, methods of seed collection, and options for seed increase.
- Support development of a community seed bank.

Uplands Recommendation 3: Reduce impact of invasive species populations on habitat quality and function.

Nonnative and invasive velvet grass (Holcus lanatus). Photo courtesy of Trent Draper

Scientific Reasoning

Invasive species are abundant in the watershed. In particular, gorse, French broom, Scotch broom, and Himalaya blackberry have reduced habitat values, increased fire hazards, and reduced rangeland quality. Removing these species and educating residents about their impacts will help restore important ecosystem functions to the uplands of the watershed.

Action 3a: Inform residents about invasive plant species, removal techniques and timing to avoid erosion and wildlife impacts, and native species suitable for residential or rangeland plantings.

Implementation Measures

- Hold a weed-whacking workshop.
- Partner with local nurseries and distributors to provide free native plants, protectors, and other revegetation products to participants.
- Provide information on websites. Distribute handouts at local events.

Action 3b: Promote removal of gorse, French broom, Scotch broom, and Himalaya blackberry infestations and replanting with appropriate native species.

Implementation Measures

- Provide use of weed wrenches for a nominal fee.
- Organize neighborhood work parties.
- Provide free native plant(s) and disposal of invasive plant material.

Action 3c: Monitor new occurrences of invasive species and contribute to regional weed management databases and efforts.

Uplands Recommendation 4: Preserve undisturbed upland habitat and its connectivity.

Scientific Reasoning

Keeping large tracts of land undeveloped is important to the health of the Salmon Creek Watershed in several ways. Many wildlife species depend on being able to move throughout large territories to find the food, water, shelter, and breeding habitat they need to survive. A few local examples include deer, bobcats, mountain lions, spotted owls, and pileated woodpeckers (Crooks 2002, George and Brand 2002). Other species have smaller territories but require adjacent patches of different habitat types for different life stages or functions. Fragmentation of habitat also has negative effects on native plant communities. Compared to intact, continuous habitat, small patches of native forest or grassland have smaller plant population sizes, greater isolation from other populations, and higher proportions of disturbed "edge" areas. As a result, fragmented plant communities are more likely to be invaded by nonnative species and to decline in diversity over time (Minor et al. 2009). Fragmentation can also reduce pollinator populations and their crucial services to native plants and some crops (Keitt 2009). Finally, maintaining large tracts of undeveloped or low-intensity agricultural land

contributes to the beauty and serenity that many residents of the watershed value, and to the ability of local agricultural producers to sustain their livelihood.

Action 4a: Identify and protect areas needed for wildlife corridors and critical habitat.

Action 4b: Encourage use of wildlife-friendly fencing.

Most fences should allow for adequate passage of non-livestock species (i.e., smaller species should be allowed to pass under or climb over freely, and deer should be able to jump over). Fences should be constructed out of materials that will prevent entanglement and should be highly visible to wildlife. They should not restrict movement through critical habitats (e.g., stream corridors, wetlands). Unneeded perimeter fencing that excludes wildlife from large areas of habitat should be avoided. Remnant fences in rural residential neighborhoods left from past agricultural operations should be removed or modified if they unnecessarily impede wildlife movement.

Implementation Measures

- Develop informational materials to post on websites and distribute at workshops, local events, and landowner visits.

Uplands Recommendation 5: Remove invasive species from coastal dunes.

Future funding is needed to develop recommendations for restoration and protection of coastal dunes in the Salmon Creek estuary.

CHAPTER 4: INSTREAM & RIPARIAN HABITAT ENHANCEMENT ACTION PLAN

Context

Intact riparian forest along Salmon Creek.

Stream systems are inherently subject to change. Vegetation distribution and channel form respond dynamically to seasonal, annual, and multi-decadal variations in precipitation and streamflow. They are also shaped by geology, topography, and climatic conditions. Riparian zone and channel processes are inextricably linked. By intercepting and absorbing rainfall and the overland flow of stormwater, vegetation moderates flood flows and filters out nutrients and other pollutants. Varied and extensive root systems hold soil, protecting streambanks from erosion. By slowing down runoff and providing root channels for water absorption, vegetation increases the water absorbed into the land and stored for later release. Reciprocally, the flow regime (magnitude, frequency, duration, timing of stream flows) influences the distribution and regeneration of riparian plants, as do the dynamics of sediment erosion, transport, and deposition within the riparian zone.

The riparian zone provides important habitat and corridors for wildlife. Where intact riparian vegetation stretches along the length of a creek, it becomes a passageway for native wildlife, linking areas of upland and downstream habitat. These passageways are crucial, especially in landscapes where uplands are developed, farmed, and fragmented. The roots and downed wood of large trees provide shelter for salmonids and other aquatic creatures. Trees shade the water and keep it cool. Allowing the riparian corridor enough space to naturally regenerate its complex of trees, shrubs, and groundcover is crucial to wildlife habitat and water quality.

Many native species have evolved to thrive in the dynamic, complex environment of the riparian zone. In many cases, their survival depends on frequent changes in stream flow, channel morphology, and sediment distribution. For example, willow and alder seeds require fresh sands and gravels left by floodwaters to germinate; salmon and steelhead require deep pools, shelter, and gravel riffles created by downed trees and the scour they generate; and amphibians need the seasonal pond features left behind by shifting channels. All riparian species depend on the floodplains formed through the processes of streambank erosion and channel migration.

Dramatic changes in channels and the riparian zone that severely alter the habitability of a stream for a population of native species are typically caused by natural disturbance regimes, such as floods, fire, or disease. Because the frequency of these large events is low and their distribution is often limited to individual reaches or sub-tributaries within a watershed, the impact of these extreme events is minimal. Native aquatic and riparian species have adapted to local disturbance regimes, which made them resilient. However, their resiliency is limited. Chronic and widespread alterations to the environment that

are outside of the natural range of variation tax individuals and eventually lead to the waning of populations.

The decline and extirpation of coho salmon in Salmon Creek is a case in point. The arrival of Europeans to the area initiated a long period of dramatic changes to the riparian zone and channel processes that, coupled with fishing pressures and altered water quality and quantity conditions, caused the salmon population to crash. The physical and biological effects of the chronic, cumulative impacts are still occurring.

Historic land-use practices have impaired streams and riparian corridors in the Salmon Creek Watershed. Channel incision, over-widening, simplification, and riparian encroachment make certain conservation and restoration activities imperative for riparian and instream habitat in the watershed:

- Instream habitat complexity in the form of large wood structures, vegetated gravel bars, and inset floodplains needs to be created to provide high-flow refugia, pools, and sediment sorting.
- Riparian forests must be protected and enhanced to provide shade, bank stability, and sources of large wood.
- Grasses and small shrubs in the riparian corridor must be protected, and be of sufficient extent, to provide bank stability and pollutant filtration.
- Delivery of fine sediment from upland sources must be reduced.
- Summer base flows must be maintained and increased to supply instream pools and the estuary with cool, oxygenated water.

Healthy riparian forest and large wood structures (installed by Dragonfly Stream Enhancement) provide complex instream channel.

Instream habitat conditions are commonly assessed in relation to the needs of coho salmon and steelhead. Conditions supportive of salmonids generally support other sensitive aquatic species. Salmonids need deep, shaded, cool pools with lots of shelter and sufficient food for successful rearing. High-quality gravel is critical for successful spawning, as well as to support macroinvertebrate production. In neighboring coastal streams, high-flow refugia is cited as being the primary factor limiting coho and steelhead populations (Stillwater Sciences 2008). Agencies tasked with protecting and recovering salmonid populations and restoring instream habitat conditions have developed habitat indicators and associated values to rank habitat quality; see Table 1.

Table 1. Selected instream habitat indicators and a value ranking system for coho salmon.

Habitat Attribute	Indicator	Ranking		
		Poor	Fair	Good
Riparian Vegetation	Species composition based on historical condition	<25%	25-50%	>50%
	Avg. Canopy Cover	<75%	75-85%	85-95%
Pool Habitat and Velocity Refuge	Frequency of primary pools*	<30% pools by length	30-40%	40-50%
	Floodplain Connectivity	<50%	50-80%	>80%
	LWD frequency	<4 key pcs/100m	4-6/100m	6-11/100m
	Shelter rating**	Score of <60	60-80	80-100
Gravel Quality and Spawning Substrate	% <0.85 mm % <6.3 mm	>17% >30%	15-17%	12-14% <30%
	% of pool tailouts with ≤50% embeddedness***	<25%	25-50%	>50%

Source: NOAA 2010.

*__Primary pools__ third and fourth order streams are defined as having a maximum depth of at least 3 feet, occupying at least half of the width of the low flow channel, and being as long as the low flow channel width (CDFG 2004d).

**__Pool shelter__ includes those elements that provide predator protection, areas of low water velocity that can be used for refuge, and separation of territorial units (CDFG 1988). It is also a useful indicator of pool complexity.

***C__obble embeddedness__ depths (the degree to which materials are buried in fine sediment) at pool tailouts are important to successful spawning of salmonids. Embeddedness ratings of 25% or less are considered desirable for spawning salmon. (CDFG 1988)

As our climate changes, functional riparian zones will likely play an even more important role in native species and habitat resiliency (Seavy et al. 2009). A defining feature of many riparian plants is their ability to withstand hydrologic and geomorphic disturbances. Thus, the impacts of increased flooding and drought, which are predicted to accompany climate change in many regions including coastal California, may be tempered by a healthy, complex riparian corridor and instream structure.

Goals

- The riparian corridor is sufficiently wide to provide shade, nutrient filtration, cover, and a sustainable source of large wood.

- The riparian corridor's vegetation density and diversity provide adequate nesting opportunities, food, and shelter and serve as corridors or islands during migration for a variety of terrestrial wildlife species.
- Instream habitat structure complexity supports fish and other aquatic species at all lifestages for robust, self-sustaining populations.
- Water quality and quantity support instream, riparian, and estuarine communities.

Instream & Riparian Recommendation 1: Protect and increase existing riparian corridors.

Scientific Reasoning

Healthy, mature riparian vegetation helps keep water cool and clean, protects streambanks from erosion, moderates flood flows, and provides roots and wood that are vital to creating the diverse habitat that salmonids and many other aquatic creatures need.

Riparian corridor along Salmon Creek in the Freestone Valley, looking southwest.
Photo courtesy of Lauren Hammack.

The benefits that riparian habitat or "buffer" zones along streams provide often depend on the width of the protected area. Recommended buffer widths depend on many variables, including local vegetation types, slope steepness, and stream hydrology. Table 2 below summarizes some key functions of riparian buffers and the widths typically needed to provide those functions.

Considering these functions, many natural resource management agencies advocate a USDA-recommended three-zone system for riparian buffers (Welsch 1991). Zone 1 is the area nearest the creek, and recommendations are typically to maintain undisturbed native forest in an approximately 15-25' wide swath. Moving out from the creek, Zone 2 is considered to be the next 50-100', with forest and understory shrubs providing wildlife habitat and allowing for some human management and thinning. Zone 3 is the outer 20-25' of the buffer and may consist of additional forest, woodland, or grassland. Even if only grasses are present, this outer zone helps slow the velocity of runoff and filter pollutants.

Table 2. Riparian buffer functions and widths.

Function	Width	Rationale & References
Nutrient reduction	10-100+ feet	Vegetated, and especially forested, riparian areas can reduce nutrient input to waterways. Plants take up nutrients and trap nutrient-rich sediments. Vegetation also supports denitrifying bacterial activity in the soil. (WDFW 1997, Martin et al. 1999) Nutrient removal efficiency of riparian buffers varies with many factors, including the types of soil, nutrients, input pathways, and vegetation involved. A USEPA review estimates that, in general, 50% nitrogen removal efficiency is achieved with a 10′ buffer, 75% efficiency with a 92′ buffer, and 90% removal with a 367′ buffer. (USEPA 2005)
Large woody debris recruitment	100-150 feet	To supply the LWD beneficial to salmonids, buffers must be sufficiently wide to support the growth and recruitment of mature large trees including redwood, Douglas-fir, and bay (WDFW 1997). A 100′ buffer typically allows for three to five mature tree widths; redwood crowns average 25-35′ wide, Douglas-fir averages 15–25′, alder averages 30-40′, and bay canopies are typically 25′ or wider (Gilman & Watson 1994).
Bank stability and reduction of fine sediment delivery	35+ feet	Roots of riparian vegetation, including rhizomatous sedges and rushes as well as woody species, can hold soil in place and reduce erosion immediately beside the creek (Rashin et al. 2006). Other research indicates additional benefits at widths of 100+ feet (WDFW 1997).
Water temperature reduction	100 feet	Increased shade from riparian trees reduces water temperature, benefiting aquatic species. 100′ buffer typically needed to provide 50-100% shading of stream (WDFW 1997).
Regeneration of diverse native riparian vegetation	150+ feet	Riparian vegetation typically contributes to a cooler, moister microclimate that supports its own regeneration. Narrow or denuded riparian areas may become hotter, drier, and less likely to support germination and growth of riparian species (Brosofske et al. 1997). Wide riparian buffers allow space for a diversity of age classes in the woody vegetation. This diversity supports the stand's ability to regenerate naturally and persist in the long term. Limited age structure complexity often indicates that riparian trees are not naturally regenerating or are not reaching maturity. Wider buffers also correlate to lower invasive species cover, leaving more opportunities for native species to regenerate. (Russell 2004)

Function	Width	Rationale & References
Wildlife habitat and corridor protection	100-2,000 feet	Mammals – In a Sonoma County study, activity level of native mammalian predators was highest in riparian areas with wide (2,200′) buffers. In narrow (65′) buffers, activity was half as great; in denuded areas, it was one-quarter as great (Hilty & Merenlender 2004). Birds – 200- 650′ (WDFW 1997). Reptiles and amphibians - 100-312′ (WDFW 1997). Invertebrates – 100′ (WDFW 1997, Warner & Hendrix 1984).

The riparian zone functions described above are impaired in the Salmon Creek Watershed. Although many reaches are shaded by vegetation, the riparian corridors are often narrow and lacking in complexity or large trees (KRIS 1994). Early logging and clearing for agricultural fields removed mature riparian trees, narrowed the riparian corridor, and simplified the channel. Residential development, livestock grazing, vineyard development, and some bank stabilization measures continue to confine the riparian corridor to an unstable width. In many stream reaches, there is only a single row of mature riparian trees at the top of bank. If streambank retreat—which is natural and desirable in incised systems such as Salmon Creek—removes the single riparian tree, the bank becomes vulnerable to rapid and unchecked erosion. In addition to destabilizing effects on the streambank, a thin canopy affects water temperature and inhibits tree re-establishment. Geomorphic assessments of Salmon Creek and its tributaries indicate that severe bank erosion occurs primarily where riparian forest is limited or absent (PCI, unpublished data).

CDFG habitat assessments rate canopy cover in the watershed as fair (averaging 65%). Canopy cover of 80% or more is considered desirable. This rating is a measure of shading of the streambed, not an indicator of corridor width, continuity, or functionality. Below-average canopy cover was noted on the mainstem and Coleman Valley, Finley, Nolan, and Thurston Creeks. With the measures described below, valuable riparian habitat can be protected and enhanced in the watershed.

Action 1a: Increase and protect riparian corridor widths to improve function and habitat quality.

Implementation Measures

- Educate landowners and residents about the benefits of riparian corridors and functional widths.
  - Develop fact sheets for distribution.
  - Develop workshops that include site visits to demonstration sites with a range of riparian conditions and land-use situations.
- Install riparian fencing along stream reaches accessed by livestock.
  - Set fences back from top of bank a minimum of two tree canopy widths, more where possible to maximize riparian functions.
  - Provide off-channel water sources.
  - Develop riparian pasture management and grazing plans.
- Develop a program to assist rural residential landowners in managing their land for wider riparian corridors.

- Develop guidance on minimizing land-use activities within the biotic resource zones.

Action 1b: Enhance riparian corridor structure complexity and species richness.

Implementation Measures

- Educate landowners along riparian corridors on the components of a healthy riparian corridor.
  - Host workshops on native species planting and invasive removal and control.
  - Produce handouts guiding landowners on riparian plant composition and landscaping for diversity.
- Plant riparian trees and herbaceous shrubs in riparian areas with insufficient density and complexity.
  - Maintain plantings until well established.

Instream & Riparian Recommendation 2: Increase instream channel complexity.

Scientific Reasoning

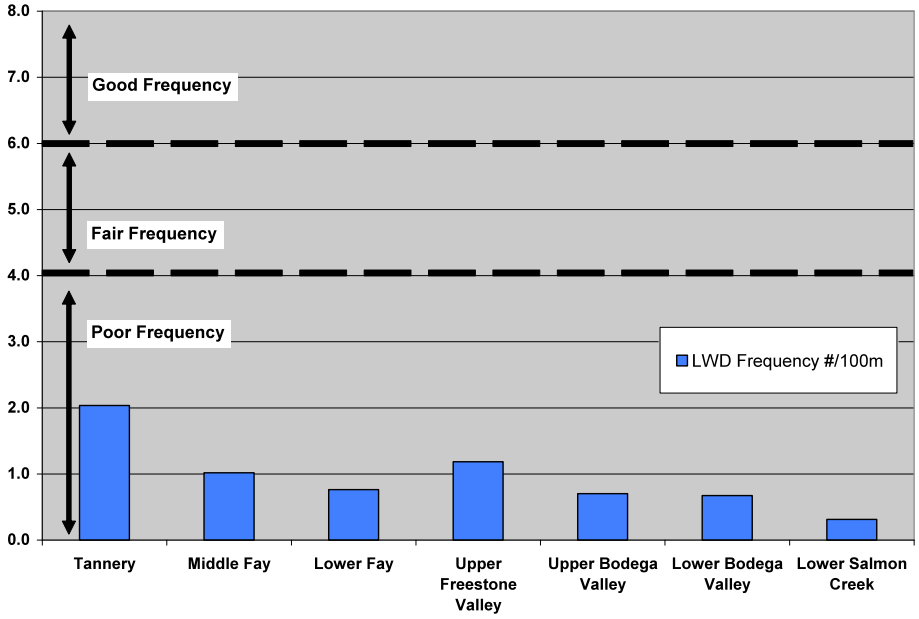
Large wood accumulations, mature trees along the active channel, and gently sloping vegetated streambanks are all needed to create and maintain instream channel complexity for high-quality aquatic habitat. Large woody debris (LWD) is an important driver for both geomorphic process (channel form as well as sediment sorting and deposition) and ecologic conditions (habitat elements, cover, and organic material input) (Opperman 2005, citing Beechie and Sibley 1997; Bisson et al. 1987; National Research Council 1996). It has been documented that coho salmon juvenile abundance is positively correlated to the presence of large wood within a stream reach (Bryant and Woodsmith 2009). In Mediterranean climate systems, such as Salmon Creek, with their low summer streamflows, the successful rearing of juvenile salmonids is likely particularly linked to the habitat value of pools associated with woody debris structure (Opperman 2005).

Naturally recruited (upper photo) and installed (lower photo) large wood structures.

Several measures of large wood frequency and its relation to instream habitat quality have been developed and used in assessing northern California stream conditions (NCRWQCB 2006a; NMFS 1996). NOAA's NMFS (2010) has set ratings for LWD frequency for streams with bankfull widths less than 10 m. Salmon Creek and its tributaries fall under the "Poor" rating with LWD frequencies ranging from 0.3 to 2.0 pieces per 100 m (Figure 4). Frequency of key large wood pieces is used as a metric of habitat quality for coho salmon and steelhead. Note that the frequency in all

reaches of Salmon Creek and its tributaries is rated as poor according to NMFS indicator targets (NOAA 2010).

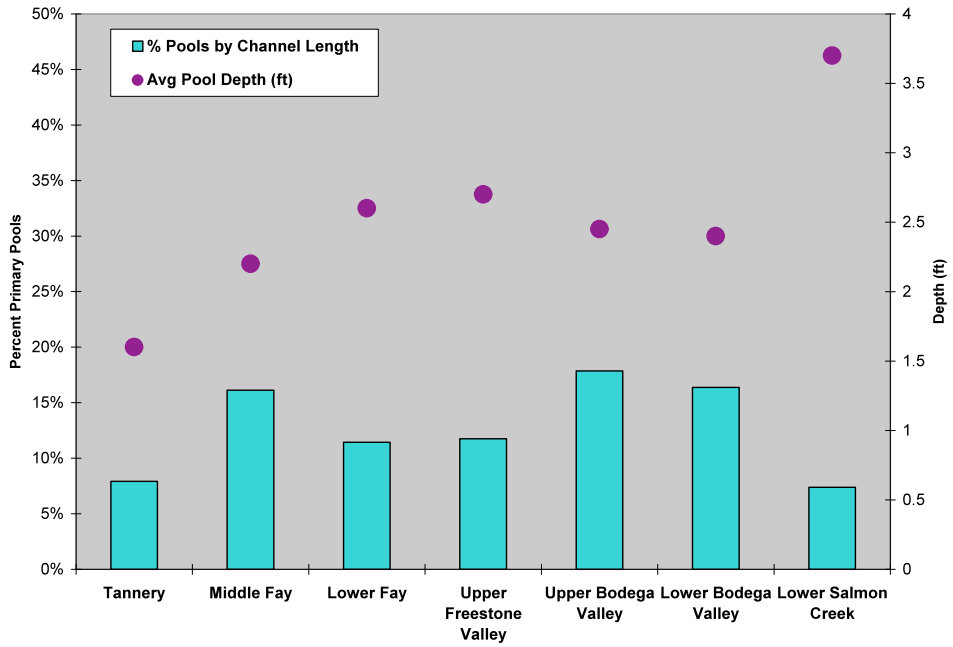
Figure 4. Frequency of key large wood pieces per 100 m.



Source: PCI 2010.

A related metric—the percent of primary pools by length—also rates "Poor." Good habitat requires 40-50% of the channel length to be pools, and, in the Salmon Creek Watershed, primary pools only account for 7-18% of the channel length (Figure 5) (PCI 2010, Appendix A).

Figure 5. Pool frequencies and depths in reaches of Salmon Creek and tributaries.



Source: PCI 2010.

In coastal, hardwood-dominated watersheds, such as Salmon Creek, live trees adjacent to the channel are key elements in the formation of pools and instream structure that support salmonids and other aquatic species (Opperman and Merelander 2007; Opperman 2005). Live mature trees, when they are located immediately adjacent to the channel, provide shade over the creek, insects and leaves to feed fish and aquatic invertebrates, and material for large wood accumulations. The complex root masses provide bank stability and, when undercut, premium habitat for salmonids and the endangered freshwater shrimp.

Riparian corridor along Fay Creek with good riparian benches but poor instream complexity for fish habitat, July 2008

Many reaches of Salmon Creek and its major tributaries are incised, disconnected from their historic floodplains, and have few inset flood benches (PCI 2010, Appendix A). Vertical, unvegetated banks maintain high velocities and are prone to erosion and bank retreat. Over time, incised channels will typically widen and establish inset floodplains, going through a series of forms commonly referred to as channel evolution (FISRWG 1998; Schumm et al. 1984; Simon 1989). This could take decades or centuries, and channel management practices such as bank stabilization attempt to arrest this process. Bank retreat in incised channels allows vertical banks to become gently sloping and inset benches to develop where riparian vegetation can establish. Vegetated slopes and inset benches stabilize banks, reduce the impacts of flood flows, and provide critical high-flow velocity refugia for salmonids.

Action 2a: Increase wood in stream channels.

Implementation Measures

- Educate landowners and residents on the importance of large wood in stream channels and the legal constraints on its unauthorized removal.
  - Develop and distribute fact sheets that address concerns of bank erosion and flooding.
  - Host workshops.
- Leave naturally downed large wood in channel unless it is threatening infrastructure.
- Install large wood structures.
- See Recommendation 1 for actions to increase available wood and promote natural recruitment through riparian corridor enhancement.

Action 2b: Allow bank widening and inset flood bench development in reaches not constrained by buildings or infrastructure.

Implementation Measures

- Use non-rock, biotechnical engineering practices to stabilize banks.
  - Slope banks back at a minimum of 2:1 slope; 3:1 or 4:1 is optimal for riparian habitat and bank stability.
  - Install floodplain benches at elevations that will be inundated at typical annual high flows.
- Allow natural bank retreat and slumping.
  - Plant slumped areas to stabilize.

Action 2c: Promote tree establishment along the active channel and on streambanks for bank stabilization, live wood complexity, and undercut bank development.

Implementation Measures

- Remove chronic disturbances, such as grazing; see Instream & Riparian Recommendation 1.
- Stabilize and slope eroding banks with bioengineering approaches and plant early successional riparian species such as willow along with hardwood and conifer species.
- Leave or install large wood on active channel margins and banks to slow flood velocities, deposit fine sediment, and protect seedlings.
- Allow undercut banks to develop.

Instream & Riparian Recommendation 3: Reduce fine sediment delivery and maintain gravel quality.

Scientific Reasoning

The presence of excessive fine sediment can degrade instream habitat and cause aquatic species population declines by inhibiting successful reproduction. For salmonids and other fish, excessive sediment can interfere with successful reproduction due to fine materials suffocating and covering eggs and larvae. Insufficient gravels can limit spawning habitat quantity and quality. High sediment loads can fill pools and lead to widespread channel aggradation.

Turbidity levels—a measure of suspended fine sediment—are chronically high during and after winter storm events in Salmon Creek and its tributaries; see Chapter 5 for details. However, assessments of streambed composition and gravel quality indicate

that there is not excessive fine sediment deposition. Gravel embeddedness (CDFG 2004; GRRCD and PCI 2007) and percent of sediment less than 0.85 and/or 6.3 mm (PCI 2010, Appendix A) rate as "Good" for coho salmon habitat in Fay Creek and other tributaries, according to NMFS indicator targets (NOAA 2010). Reaches along mainstem Salmon Creek in Freestone and Bodega Valleys do not meet the sediment composition criteria for good spawning and incubation habitat; however, these reaches are geomorphically predisposed to fine sediment deposition and are not out of equilibrium (PCI 2010, Appendix A).

Historic land-use practices, such as clear-cut logging, crop production, and high-density livestock operations, led to accelerated erosion (PCI 2006; GRRCD and PCI 2007). While these intensive land use practices have largely ceased, the impacts of the increased sediment loads are still seen in the stream system with low pool depths and accelerated aggradation in lower Salmon Creek and the estuary (PCI 2006). Currently, upland gullies, landslides, residential development, and roads are the main sources of fine sediment in the watershed (GRRCD and PCI 2007; PWA 2006). Compacted road surfaces produce fine sediment. Old ranch and logging roads often have failing ditches and culverts that cause wash outs and gullies. Road ditches concentrate runoff and transport sediment directly to streams. Properly designed and maintained roads can significantly reduce sediment delivery to streams (Weaver and Hagans 1994).

Action 3a: Reduce fine sediment delivery from upland gully erosion, residential development, livestock operations, vineyards, and roads.

Implementation Measures

- Educate landowners, construction operators, and public works departments on BMPs for reducing erosion and managing sediment delivery to streams.
  - Hold public workshops on stormwater management and road maintenance practices.
  - See Chapter 3 for additional suggestions.
- Improve grasslands and cross-fence pastures to reduce sheet and rill erosion on livestock ranches and dairies.
- Install riparian fencing to reduce streambank erosion.
- Decommission non- or under-used roads.
- Upgrade poorly designed roads.
- Document and repair upland gullies delivering sediment directly to the stream system.

Action 3b: Improve in-channel complexity for the capture and sorting of suitable spawning gravels.

See Instream & Riparian Recommendation 2.

CHAPTER 5: WATER QUALITY MANAGEMENT ACTION PLAN

Context

Water quality is of utmost importance to human and ecosystem health. All terrestrial and aquatic life relies on pollutant-free fresh water to thrive. The quality of surface waters—streams, wetlands, ponds, and shallow groundwater—is dependent upon physical factors and processes in the uplands and along the riparian corridors. See Chapters 3 and 4 for more information on these related ecosystem processes.

Beneficial uses within a watershed are determined by the Regional Water Quality Control Boards (Regional Board) based on climate, topography, geology, hydrology, and native aquatic species. The waters of Salmon Creek are listed as providing the following beneficial uses:

- Water supply for agriculture (AGR), industrial services (IND), and municipal domestic use (MUN),
- Contact (REC1) and non-contact recreational use (REC2),
- Commercial and sport fishing (COMM),
- Navigation (NAV),
- Groundwater recharge (GWR),
- Cold freshwater habitat (COLD),
- Migration of aquatic organisms (MIGR),
- Spawning, reproduction and/or early development of fish (SPAWN),
- Estuarine habitat (EST),
- Wildlife habitat (WILD),
- Habitat for rare, threatened, and endangered species (RARE),
- Water supply for industrial processes (PRO-potential),
- Aquaculture (AQUA—potential), and
- Shellfish Harvesting (SHELL—potential).

If water quality conditions are documented to be outside the standards for a given beneficial use, the RWQCB may recommend to the U.S. Environmental Protection Agency (USEPA) that a watershed should be listed[4] as impaired for that parameter. For example, many streams in the North Coast region[5] are listed as impaired due to high sediment and nutrient loads because their levels within the watershed are negatively impacting aquatic habitat and threatened or endangered fish population success. The Salmon Creek Watershed is not listed as impaired for any beneficial use or water quality parameter (NCRWQCB 2009).

The Salmon Creek Watershed Council (SCWC), PCI, and GRRCD started a citizen water quality monitoring program in Salmon Creek with CDFG funding in 2004 to document and track baseline water quality conditions at 13 sites (GRRCD and PCI 2007). (See

[4] Section 303(d) of the federal Clean Water Act and 40 CFR §130.7 require states to identify waterbodies that do not meet water quality standards and are not supporting their beneficial uses. These waters are placed on the Section 303(d) List of Water Quality Limited Segments (also known as the list of Impaired Waterbodies). The list identifies the pollutant or stressor causing impairment and establishes a schedule for developing a control plan to address the impairment. (http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/303d/)

[5] In 1980, the State Water Board, the Department of Water Resources, and the U.S. Geological Survey entered into an agreement that redefined the hydrologic basin planning areas within the State of California. The North Coast Region is Hydrologic Unit Number 1 (NCRWQCB, 2007).

Figure 12: Water Quality Monitoring Sites Map.) This volunteer program is still running and has been supported through diverse funding sources to purchase and maintain equipment (Sonoma County Fish and Wildlife Commission, The Hart Foundation, public donations collected at local businesses, and through ongoing, voluntary donations of both staff time and money from GRRCD). The volunteers conduct monthly monitoring of dissolved oxygen (DO), turbidity, temperature, nitrates, phosphates, salinity, pH, and free and total chlorine.

In 2007, GRRCD implemented a more rigorous and focused monitoring protocol with Surface Water Ambient Monitoring Program (SWAMP) guidelines at 8 additional sites for those parameters listed above, as well as total suspended solids (TSS) and conductivity. PCI, through a State Coastal Conservancy grant to OAEC, monitored DO, salinity, temperature, and turbidity in the estuary from June 2004 to June 2005 and storm-related turbidity at 14 upstream sites during the 2004/2005 rainy season.

Gold Ridge RCD staff monitoring water quality in Tannery Creek.

As part of a study of 5 northern California estuaries, UCCE analyzed sediment and water samples at 5 locations in the estuary for fecal coliform and *E.coli* from August 2004 through June 2005 (UCCE 2007). Data was also collected on discharge, temperature, DO, salinity, turbidity, and TSS. During the study period, fecal coliform levels in the Salmon Creek estuary exceeded Regional Board criteria for shellfish harvesting and non-contact recreation.

UCCE analyzed the results of the watershed monitoring efforts and concluded that, given the existing data, "overall, water quality was fair to good in the Salmon Creek Watershed, with tributary streams exhibiting better conditions than the mainstem." (Appendix A). However, monitoring programs indicated that the following water quality parameters sometimes tested outside optimal levels for salmonids and other aquatic organisms:

- High **turbidity** levels during and after winter storms,
- High **temperatures** during summer in the creeks and estuary,
- Low **DO** levels during summer in pools and in the estuary, and
- High **bacterial levels** in the estuary.

Table 3 indicates targets or objectives for these parameters.

Table 3. Targets or objectives for selected water quality parameters in Salmon Creek.

Parameter	Target/Objective	Source
Dissolved oxygen (DO)	At least 7 mg/L at all times to support the beneficial uses defined for Salmon Creek Watershed and at least 9 mg/L during critical spawning and egg incubation times from November to May	NCRWQCB 2006a
Turbidity	Not to exceed 55 NTU over several days, or 400 NTU for a few hours	Newcombe 2003
Temperature	15° C Maximum Weekly Average Temperature (MWAT)	NOAA 2010
Fecal coliform	Median 30-day levels (based on a minimum of 5 samples/30 days) should not exceed 50/100 ml and that no more than 10% of those samples should exceed 400/100 ml	NCRWQCB 2006a

Although standard water quality parameters are tested through the Salmon Creek monitoring programs, many water quality contaminants linked to human and environmental health have not been tested due to the costs and complexities of sampling and analysis. Inadequate septic systems and agricultural runoff can release *E. coli*, other pathogens, pharmaceuticals, and hormones. Pesticides, herbicides, heavy met als, and petroleum-based pollutants are washed off the ground and road surfaces during rainfall events and transported to the creeks by stormwater runoff. Bacteria and the chemical constituents of toxic substances can concentrate in the water and fine sediments over time. Depending on their levels in the system, they can directly affect human and wildlife health, or they can slowly build up in organisms and concentrate within the food chain. Salmonids have been found to be particularly sensitive to pesticides, herbicides, and other compounds common in most freshwater systems (Laetz et al. 2009; NOAA Fisheries 2008).

Improving water quality where needed in the Salmon Creek Watershed and maintaining existing good quality entails addressing known pollutant sources, using effective management practices to prevent pollution, and enhancing the natural processes that sustain clean, cool water. Stormwater runoff is the primary non-point source pollutant delivery system in rural watersheds such as Salmon Creek. Rainwater carries loosened soil and animal wastes from ranches and residential yards.

Exposed soil from construction or certain agricultural practices is vulnerable to erosion. Water flowing over impervious surfaces, such as roads, buildings, and driveways, collects and concentrates pollutants. Compacted, unpaved soil—common on rural driveways and the network of logging and ranch roads throughout the watershed—behaves as an impervious surface and produces fine sediment that washes into

waterways during each runoff event. Poorly maintained or inadequate septic systems in the riparian corridor and unrestricted livestock access to waterways are other direct pollutant sources.

Maintaining high water quality for human and ecosystem health is possible through careful stormwater management and reducing the use of toxic materials. Upland vegetation management and restoration are key factors in protecting water quality; see Chapter 3. A robust, naturally functioning riparian corridor is also critical for filtering contaminants and maintaining cool, well-oxygenated water; see Chapter 4.

Table 4. Summary of potential pollutants and sources in the Salmon Creek Watershed.

Pollutant	Potential Sources		Impacts on Waterbody
	Point Source	**Non-Point Source**	
Pathogens	Dairy or Confined Animal Feeding Operation (CAFO)	• Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure	• Primarily human health risks
Metals	• CAFO • Urban Runoff	• Hazardous waste sites (unknown)	• Aquatic life impairments • Risk to livestock • Fish contamination
Nutrients	• CAFO	• Lawns • Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure	• Aquatic life impairments • Recreational impacts • Human health impacts • Habitat impacts
Sediment		• Rangeland erosion • Streambank erosion • Landslides & gullies • Urban runoff • Roads • Construction	• Aquatic habitat impairments • Recreational impacts • Navigational impacts • Hydrologic impacts • Habitat impacts
Temperature		• Sediment (turbidity increases stream temperatures) • Lack of riparian shading • Shallow or wide stream channels (due to hydrologic modification)	• Aquatic life impairments • Recreational impacts

Goals

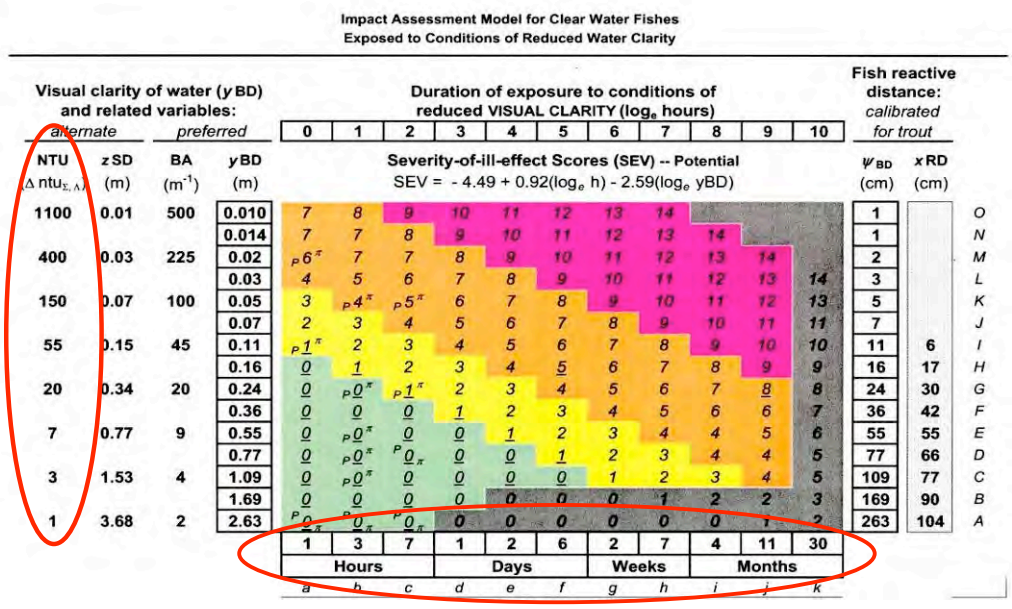
- Water quality conditions in Salmon Creek, its tributaries, and the estuary meet or exceed all regulatory targets.
- Water quality conditions support salmonid fish and other aquatic organisms at all lifestages.
- Sediment and contaminants in the water are at levels that do not harm the health of plants, wildlife, and humans.

Water Quality Recommendation 1: Minimize turbidity and the delivery of fine sediment from upland sources.

Scientific Reasoning

Turbidity, measured in nephelometeric turbidity units (NTU), is a measure of the amount of light reflected through a sample of water—it can also be thought of as lack of water clarity. Total suspended solids (TSS), which measures the weight per volume of the sediment load suspended in the water column, is another measurement technique to evaluate suspended solid levels. Turbidity has been scientifically correlated to TSS and is used as a proxy for the amount of suspended solids in water. Increases in turbidity are caused by sediment from soil erosion and roads; particulate matter from sewage, rural and urban runoff, and livestock; and algal blooms caused by excess nutrients (USEPA 1997). Elevated stream turbidity can be used as a measure of the effect of human land use on stream systems (MacDonald et al. 1991). During summer low-flow conditions in nonimpacted streams, normal background turbidity is generally less than 5 NTU (CCWI 2008). In winter, during rainfall runoff events, it is typically higher.

Figure 6. Matrix of impairment levels by turbidity level and duration.



Yellow indicates slight impairment with changes in feeding and other behaviors, orange indicates significant impairment with altered fish growth and habitat quality, and red indicates severe impairment with physiological condition changes and habitat alienation (Newcombe 2001, 2003).

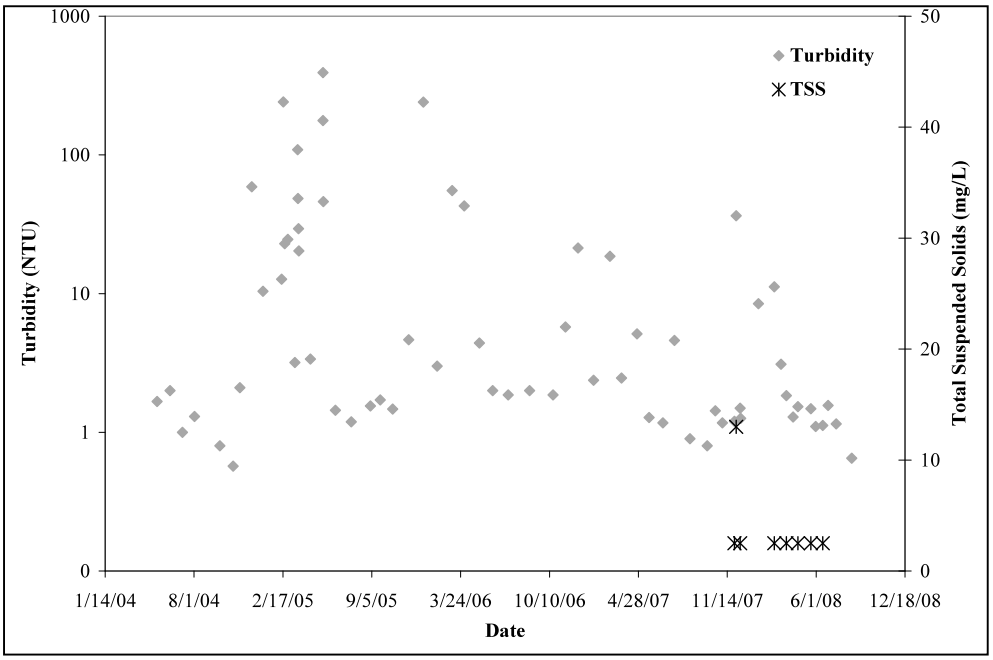
High levels of turbidity may indicate high levels of suspended solids, which can lead to excess fine sediment deposition and smothering effects on benthic organisms, fish eggs, and larvae. Extended periods of high turbidity can alter salmonid behavioral responses and can induce physiological changes in aquatic organisms (Newcombe 2003; Schwartz et al. 2008; UCCE 2009). The detrimental effects of turbidity on fish increase in relationship to the duration of turbid conditions. High levels of suspended solids expressed by turbidity measurements above 55 NTU over several days or weeks, or 400 NTU for a few hours, cause significant impairment to salmonids (Figure 6; Newcombe 2003). High levels of suspended solids can kill fish, and sublethal levels can have long-

term physiological effects. Juvenile and adult salmonids show physiological stress and impaired feeding behavior when exposed to TSS over 300-500 mg/L (McLeay et al. 1987; Servizi and Martens 1987, 1992; MacDonald 1991). Excessive fine sediment that drops out of the water column reduces the quality of salmonid rearing habitat by filling interstitial spaces and, thus, effectively lowering the level of dissolved oxygen that reaches eggs and emerging fry in streambed gravels (UCCE 2009).

High turbidity levels can have an impact on beneficial uses other than fisheries and aquatic organisms. It can impact near- or instream water supplies by decreasing potability and increasing treatment requirements and costs. Heavy metals, such as mercury, pathogens, and toxins, may bind to fine sediment particles in the water column. Concentration of these pollutants in sediment deposits throughout the stream system can impair beneficial uses, such as water supply, contact recreation use, estuarine habitat, and shellfish harvesting.

Water quality monitoring data and instream habitat assessments indicate that excessive fine sediment delivery and deposition and associated high turbidity levels may be the primary water quality issue impacting ecological function and salmonid success in the Salmon Creek Watershed (CDFG 2004; GRRCD and PCI 2007). Appendix A summarizes baseline water quality monitoring data—including turbidity and TSS measurements—collected by volunteers and GRRCD from 2004 through 2008. Data graphs displaying monthly turbidity measurements for multiple locations throughout the watershed show dramatic seasonal variation between the dry, low-flow summer months and wet, high-flow winter period; see Figure 7 for measurements taken at Salmon Creek School.

Figure 7. Turbidity measurements at Salmon Creek School.

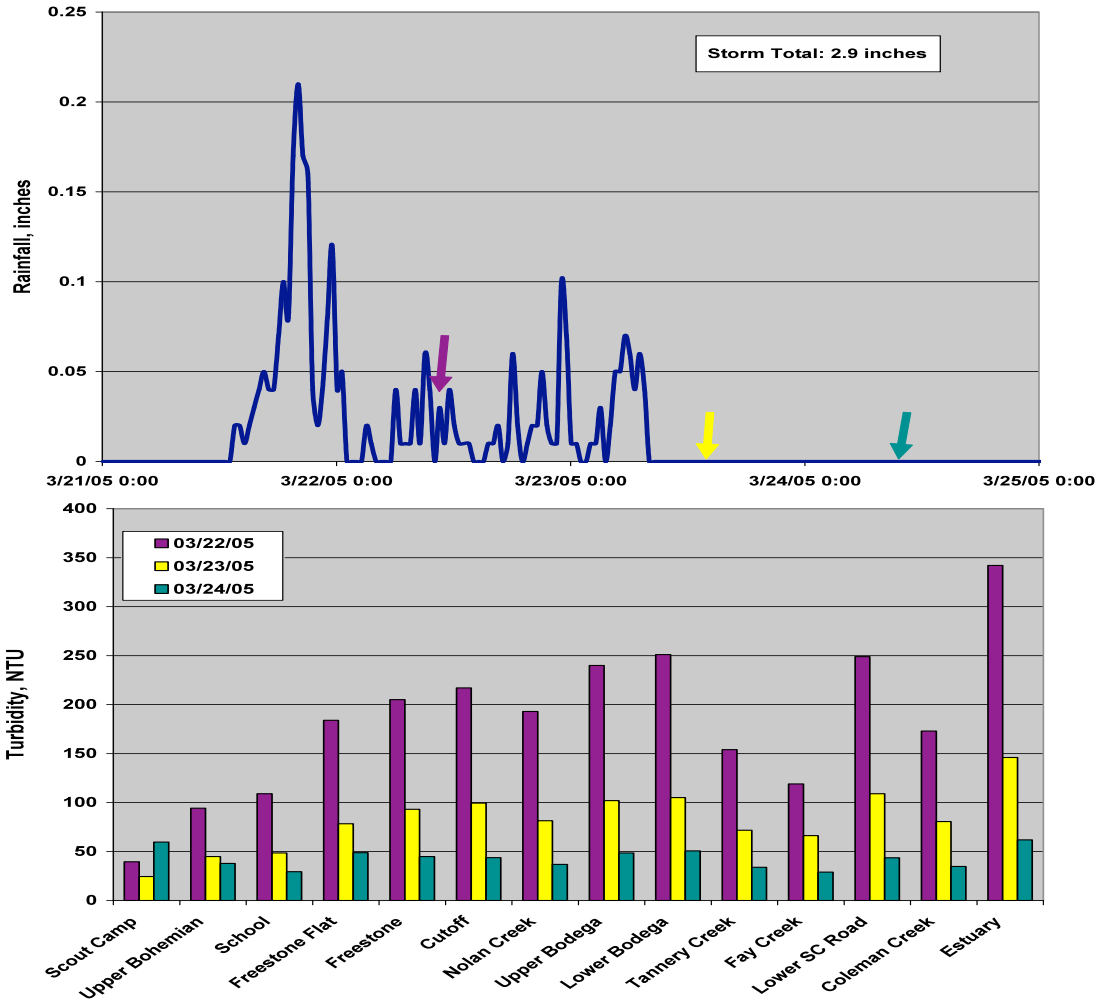


Source: UCCE 2007.

Although turbidity values under low-flow conditions appear to be at or below the 5 NTU suggested background level, high-flow season turbidity levels are frequently well above 10 NTU, with storm-related turbidities in the 100 to 1,000 NTU range. Increased turbidity during rainfall and runoff events is expected to occur naturally in Salmon

Creek given its geology, topography, and precipitation patterns. In addition, it appears that Salmon Creek—based on visual observations of water clarity in the winter by residents—remains turbid longer after storm events compared to neighboring watersheds. As discussed above, extended periods of elevated turbidity can have detrimental effects on salmonids and other aquatic organisms.

Figure 8. Correlation between rainfall and turbidity levels in March 2006 storm.



Storm-related turbidity data were collected by PCI in 2005 (GRRCD and PCI 2007) and GRRCD in 2006 (Appendix A, UCCE 2009) in which measurements were collected on successive days of a storm to document persistence of excessive turbidity levels. The graphs in Figure 8 are an example of data collected during a 2.9-inch rainfall that occurred over a 36-hour period. During the middle of the storm, but after the peak intensity, turbidity values are in the "significant impairment" range (Figure 8; Newcombe 2003). It can be reasonably assumed that these high turbidity levels persisted throughout the rainfall event. Within several hours of rainfall cessation, turbidity fell below 100 NTU but was still above 55 NTU, keeping the water quality in the "significant impairment" range. Three days after the start of the rainfall, turbidity levels were below 55 NTU but still not down to background levels.

Standard approaches to reducing storm-related high turbidity levels focus on preventing delivery of sediment to drainages through controlling upland erosion sites, maintaining rural roads, and managing runoff from livestock-impacted areas and home sites. Once sediment and other particulate matter are in the stormwater drainage system, retention and settling ponds can be used to trap material before it enters the streams.

WQ Action 1a: Document and manage upland sediment sources.

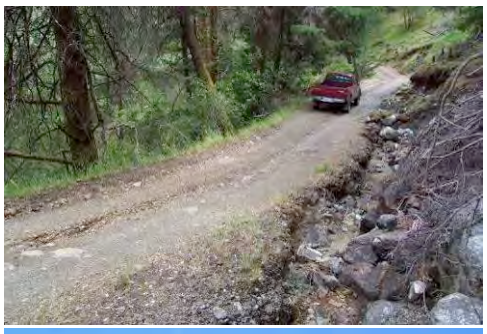
Implementation Measures

- Assess upland erosion sites for delivery of sediment to waterways.
  - Active gullies connected to the stream system.
  - Other sources of large fine-sediment loads, such as landslides.
- Maintain an on-going inventory of high-priority erosion control projects for use in funding and implementation decisions.
- Cooperate with landowners to implement identified high-priority erosion control projects.

WQ Action 1b: Maintain, improve, or decommission rural roads.

Implementation Measures

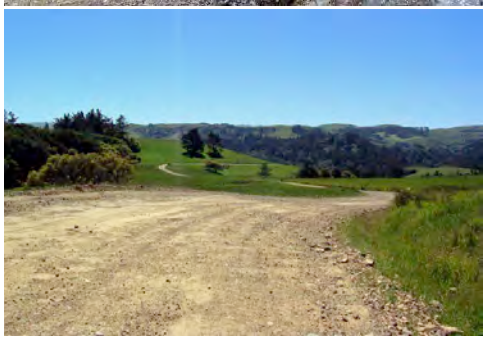
- Address sediment sources from road networks. Where possible, decommission roads that are no longer in use.
- For roads that are still in use, improve road design and maintenance practices to limit sediment production.
- Provide maintenance workshops and install demonstration projects as outreach to owners of dirt roads and driveways.



WQ Action 1c: Disconnect and filter sediment from waterways.

Implementation Measures

- Increase the width, extent, and vegetative cover of riparian buffer throughout the watershed; see Instream & Riparian Habitat Enhancement Action Plan in Chapter 4.
- Provide off-channel water sources for livestock by developing alternative water supply and providing pasture troughs.
- Construct sediment retention basins and infiltration swales along roadway drainage ditches to capture stormwater runoff and fine sediment.
- Install bioswales to slow stormwater runoff before it enters waterways
- Disconnect impervious surfaces



Examples of fine sediment-producing features on the landscape.

WQ Action 1d: Promote soil retention.

Implementation Measures

- Provide technical information and training on Best Management Practices for erosion control and farming practices to maintain topsoil.

Water Quality Recommendation 2: Maintain and improve summer water temperatures.

Scientific Reasoning

Water temperature is important to fish and other aquatic species, as well as the function of the aquatic ecosystem. It influences the rate of metabolism for many organisms, including photosynthesis by algae and other aquatic plants, as well as the amount of oxygen that the water can hold. Salmon Creek is a coldwater system, and native species are adapted to a specific range of water temperatures. California red-legged frogs typically lay their eggs in water about 16 °C. Embryos have a critical thermal maximum of 21° C (Cook 1997). Coho eggs have even more restrictive requirements, with eggs needing 35-50 days of water temperatures from 9-11° C (Shapovalov and Taft 1954).

Both of these species lay eggs at cooler times of year to accommodate temperature requirements. However, adult fish and rearing juveniles must cope with summer maximums. Rearing juvenile steelhead begin to show stress at maximum weekly average temperatures (MWAT) greater than 17° C, and juvenile coho show stress above 14.8° C (Sullivan et al. 2000), although coho studied in Russian River tributaries do not show marked decreased survival until maximum weekly average temperatures reach 22° C (Obedzinski et al. 2008). The NOAA Fisheries Service coho recovery plan defines good habitat as less than 15° C MWAT (NOAA 2010).

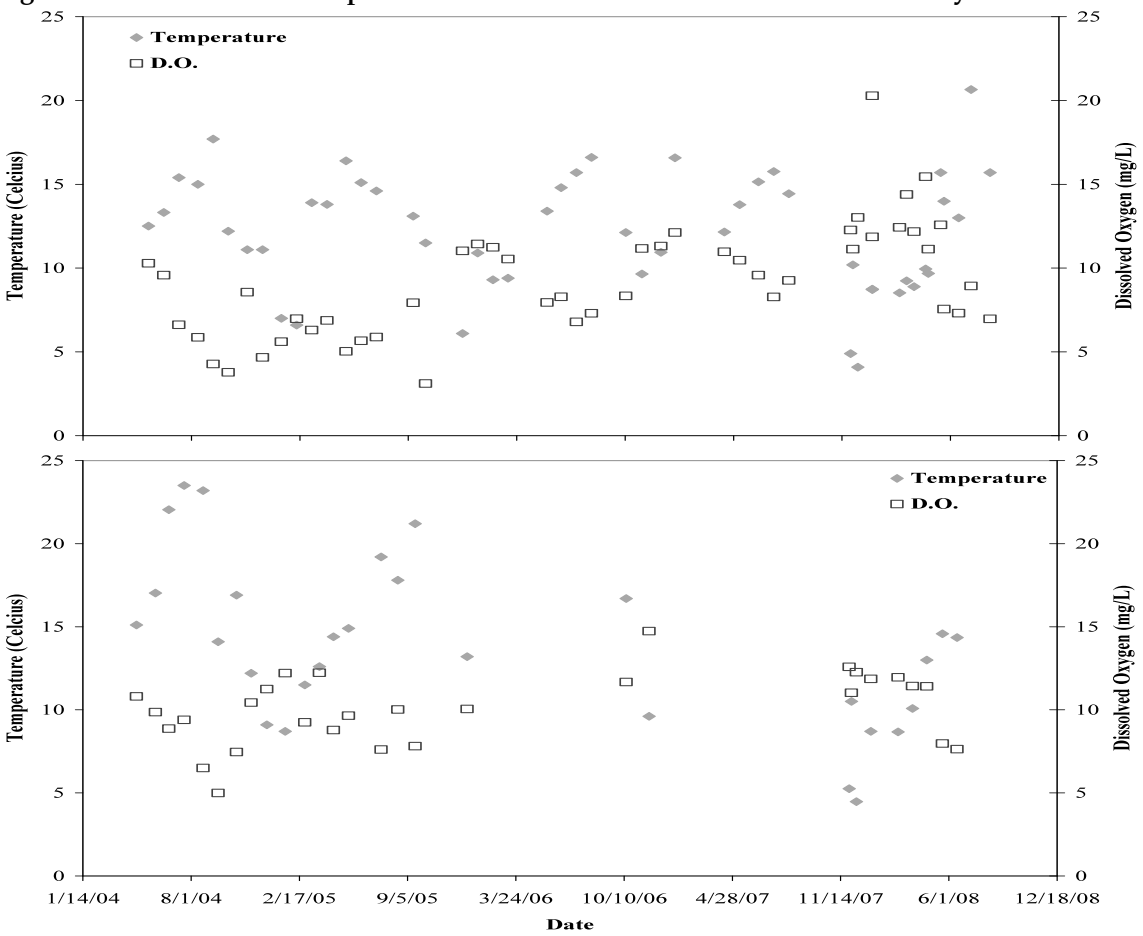
Temperature is influenced by:

- Ambient air temperature—Direct heat transfer occurs between air and water, with the warmer giving heat to the cooler. However, water temperatures change more slowly than air temperature.
- Volume and depth of water—Greater volumes of water take longer to adjust to changes in air temperature. The water at the bottom of deep pools will adjust more slowly than water at the surface and provide temperature refuges for salmonids and other species.
- Streamflow connectivity—Where groundwater continues to feed surface water during the dry months, the water coming from underground will generally be cool and fairly temperature stable. As long as the water has sufficient flow to maintain connectivity, there is a continuous cool water input to the system.
- Turbidity—Suspended solids directly absorb more heat than a clear water column.
- Shade—The extent and density of riparian canopy contribute directly to cool water temperatures.

Deep shade in Tannery Creek keeps water temperatures low.

- Salinity stratification—As freshwater inputs to the estuary decline and the bar at the mouth prevents mixing with ocean water, a lens of fresh water develops at the top of the estuary surface and focuses solar radiation on the salty layer below, which, in turn, heats the water. In 2004, estuary temperatures reached 31.6° C (89° F) (PCI 2006).
-

Figure 9. Seasonal water temperature and DO variations in the Freestone Valley.



Source: UCCE 2007.

Based on the data collected, water temperatures in Salmon Creek and its tributaries are generally supportive for salmonids and other aquatic organisms. Water temperatures increase during summer months when ambient air temperature is higher and streamflows are lower, and many monitored locations routinely exhibit temperatures between 15° C and 20° C during this period (Appendix A, UCCE 2009). The two graphs in Figure 9 represent sites within the Freestone Valley and illustrate the seasonal patterns in the watershed. Water temperatures in the mainstem through Freestone and Bodega Valleys tend to be higher in the summer than in the tributaries.

The baseline water quality monitoring occurs primarily at publically accessed locations, such as bridges. Summer water temperatures at critical salmonid rearing locations may locally exceed optimal conditions due to insufficient riparian cover density and pool depths or excessive turbidity levels, while other locations may be cooler due to dense shading and consistent groundwater supplies.

Because of the direct connection to fish and aquatic health, it is imperative to maintain and improve water temperatures throughout the watershed, especially during the hot, dry summer season. Dense riparian canopy cover shades the stream and lowers ambient air temperatures. Groundwater inflows and perennial streamflows supply cool water to pools. Nutrients, fine organic material, and sediment suspended in the water absorb heat and cause algal blooms.

Stagnant, hot water with excessive algae. Photo courtesy of Lauren Hammack (PCI)

WQ Action 2a: Maintain and enhance dry-season flows.

See Chapter 6: Water Supply Sustainability Action Plan.

WQ Action 2b: Maintain and Increase riparian canopy cover.

See Chapter 5: Instream & Riparian Habitat Enhancement Action Plan.

WQ Action 2c: Reduce and minimize turbidity.

See Water Quality Recommendation 1.

Water Quality Recommendation 3: Increase summer DO levels in pools.

Scientific Reasoning

The amount of oxygen dissolved in water influences growth, reproduction, survival of aquatic organisms, and species diversity. Higher water temperatures and nutrient overloading, such as organic wastes, tend to lower DO, while photosynthesis and turbulence in the water increase DO. Levels can vary rapidly, but even short episodes of very low oxygen can cause critical impairment and mortality to aquatic organisms. The *North Coast Regional Water Quality Control Board Basin Plan* requires DO concentrations of at least 7 mg/L at all times to support the beneficial uses defined for Salmon Creek Watershed and at least 9 mg/L during critical spawning and egg incubation times from November to May (NCRWQCB 2006a).

Cool water flowing over riffles maintains high DO levels in pools.

DO levels in Salmon Creek below the NCRWQCB's 7 mg/L target have been measured at 14 of the 17 sites during the 4-year baseline water quality monitoring program (Appendix A, UCCE 2009). These low DO conditions occurred throughout the year, but they are observed more frequently during the dry season. The only sites that did not experience periods of low DO are the headwater sites on the mainstem and Tannery Creek. Instances of DO concentrations below the NCRWQCB's 9 mg/L target during spawning and egg incubation periods occurred at 12 of the 17 sites. Example monitoring

data are shown in Figure 9 from sites in the Freestone Valley (from Appendix A). Note the correlation between low DO concentrations and high water temperatures.

DO concentrations below 3 mg/L, which are noted as lethal to juvenile and adult salmonids by Raleigh et al. (1984) and McMahon (1983), occur in Salmon Creek and its tributaries during late summer. The monitoring program picked up 7 instances of DO below 3 mg/L at the monitoring sites (Appendix A). In addition to the baseline monitoring measurements documented in Appendix A, DO concentrations were measured at pools in Fay Creek, Finley Creek, and mainstem Salmon Creek in the Bodega and Freestone Valleys in summer 2009 as part of the juvenile coho rescue program (Table 5). Pool DO levels in several of the critical rearing habitats were well below 3 mg/L; however, the rescued juvenile coho and steelhead appeared healthy (Michael Fawcett, pers. comm., November 2009).

Table 5. DO and water temperature measurements at critical coho rearing habitat locations during drought conditions, August 2009.

Location	Date	DO (mg/L)	Temp (^{0}C)
Finley Creek	08-28-09	1.6-2.4	14-15
Fay Creek	08-08-09	<5.0	13-15
Fay Creek	Aug -09	1.9-2.5	~14
Salmon Ck – Bodega	08-08-09	2.6-4.6	14
Salmon Ck – Bodega	08-22-09	0.1-1.2	12-14
Salmon Ck – upper Bodega Valley	08-28-09	7.2-7.9	15
Salmon Ck - Freestone	08-26-09	7.2	16

Source: Michael Fawcett, pers. comm., November 2009.

Good pool DO levels are observed to be primarily associated with freshwater surface flows upstream, while pools with very low DO are disconnected and stagnant. Thus, maintaining sufficient streamflows in the summer to keep pools connected and aerate the water as it flows over the riffles and bedrock ledges is a high priority. Cool water temperatures help keep DO levels high, as does minimizing the nutrients inputs.

WQ Action 3a: Increase summer streamflows.

See Chapter 6: Water Supply Sustainability Action Plan.

WQ Action 3b: Reduce summer water temperature.

See Water Quality Recommendation 2.

WQ Action 3c: Reduce nutrient loads.

See Water Quality Recommendation 4.

Water Quality Recommendation 4: Minimize nutrient and pathogen delivery.

Scientific Reasoning

Inorganic nutrients, including phosphorus and nitrogen are abundantly found in nature and necessary for plant and animal growth. However, inorganic nutrients, primarily from animal waste, may be discharged into Salmon Creek and its tributaries during rainfall runoff events. Nutrients can cause environmental problems in a variety of ways. Un-ionized ammonia (a reduced form of nitrogen) is toxic and can be present in such high concentrations that it kills aquatic organisms. In aquatic ecosystems, nutrients can cause blooms of algae. In coastal waters, nitrogen is the nutrient of concern causing overfertilization of aquatic plants. In freshwater systems, phosphorus is the nutrient of concern. Algal blooms and the die-off of aquatic plants cause oxygen depletion in the water column, resulting in poor habitat conditions for aquatic species (Appendix A). The subsequent decay of algae depletes DO and renders water unfit for most or all of the beneficial uses of Salmon Creek. Fertilizers, human and animal wastes, and the use of phosphate detergents all contribute to nutrient levels in the creeks (USEPA 2008).

The *North Coast RWQCB's Basin Plan* states that sufficient information is not yet available to develop numeric nutrient criteria in our region but that levels should be maintained below those that will cause eutrophication or impacts to beneficial uses (NCRWQCB 2006a). Eutrophication is the process by which streams or lakes become enriched with nutrients that stimulate the growth of aquatic plants that, in turn, deplete dissolved oxygen. The EPA guidance on establishing standards gives any rise above baseline conditions as the possible non-numeric criteria (USEPA 2000a). The EPA has set reference guidelines for protection against eutrophication, which state that nitrates should not exceed 0.155 mg-N/L and orthophosphate (reported as total P) not exceed 0.03 mg/L (USEPA 2000).

UCCE analysis of the nutrient data collected concluded that "nutrients were very low on average across subwatersheds" with only one sample from the estuary showing a nitrate level that exceeded the EPA recommendations to prevent eutrophication (Appendix A). The UCCE report also noted possible uncertainties for both nitrate and phosphate results due to the testing methods used in the Salmon Creek Watershed and recommended that methods for these parameters be evaluated to ensure accuracy (Appendix A). Watershed residents have noted pools in middle and lower Salmon Creek with algae, amber color, and unpleasant odor during summer low-flow conditions—potential indicators of high nutrient concentrations and possible pathogens.

Algae bloom in Bodega Valley, 2008.
Photo courtesy of Lauren Hammack (PCI)

Pathogens, microbes that cause disease, were not tested in the freshwater portion of the watershed. UCCE sampled fecal coliform and *E. coli* at 5 sites from the mouth to 1.3 km (0.8 mile) inland. Samples were taken from both the water column and the estuarine sediments during wet season storm flows, winter base-flow conditions, and summer base-flow conditions. Mean fecal coliform concentrations were above water quality criteria during all 3 testing seasons for shellfish harvesting and above the criteria for non-contact recreation during wet season storm flow conditions. The report concluded that "contaminated freshwater inflow that enters the estuary, especially during

stormflow conditions, is the primary transport pathway" (UCCE 2007). Freshwater inflow points to upstream land-use activities as the source of bacteria, not a reworking of coliform stored in the estuarine sediments. Of the 5 estuaries studied by UCCE, however, Salmon Creek had the highest concentration of fecal coliform in the estuarine sediments with an unusual pattern of increasing levels towards the mouth (Lewis 2010).

Human and animal wastes are the primary sources of pathogens. In the Salmon Creek Watershed, potential sources of pathogens include poorly maintained or inadequate septic systems, unrestricted livestock access to streams, runoff from confined animal areas, and poor management of livestock and other domestic animal waste. GRRCD, NRCS, and UCCE all have extensive expertise and information to assist ranchers, dairy farmers, and horse owners with selecting and implementing animal waste management practices to prevent transmission of pathogens from livestock into surface water.

The actions below are intended to prevent excessive nutrients and pathogens from entering Salmon Creek and its tributaries.

WQ Action 4a: Restrict direct livestock access to streams and riparian areas.

Implementation Measures

- Provide technical information to horse owners and other rural residents with small numbers of confined animals.
- Support use of riparian fencing, pasture management, water development, and other strategies to protect waterways.

WQ Action 4b: Upgrade inadequate septic systems adjacent to waterways.

Implementation Measures

- Provide information to landowners on the importance of maintaining a well-functioning septic system to a healthy stream.
- Coordinate with Sonoma County PRMD to streamline permitting to upgrade or replace inadequate systems.
- Seek funding to assist landowners with onsite wastewater treatment systems.

WQ Action 4c: Reduce use of nitrate- and phosphate-rich products.

Implementation Measures

- Develop and distribute a comprehensive list of effective alternatives and methods for reducing quantity of use.
- Develop demonstration sites for reduced fertilizer and pesticide gardening and farming.
- Educate landowners about reducing the use of phosphate soaps to lessen associated phosphate pollution through insufficient filtration by onsite wastewater treatment systems.

Water Quality Recommendation 5: Promote minimal use and proper disposal of toxic compounds.

Scientific Reasoning

Toxic compounds occur in some pharmaceuticals, petroleum products, herbicides, pesticides, and common household substances, such as cleaning solutions, paints, solvents, and swimming pool chemicals. When these compounds enter waterways, they can cause acute or chronic effects in aquatic wildlife. Acute effects include death and disruption of critical life events. Chronic effects can weaken organisms and cause subtle

changes in behavior that compromise breeding success and survival. Adult and juvenile salmonids are increasingly showing sublethal and lethal responses to mixtures of toxic pollutants commonly found in most streams (NOAA Fisheries 2008, Laetz et al. 2009). Research currently underway by the NOAA Coastal Storms Program based in Seattle on mysterious mortality of coho using recently restored urban streams has revealed that spawner mortality rates are much higher immediately after storm events. Investigation into the cause of fish mortality shows that the fish are being subjected to high levels of urban pollutants carried by the stormwater (NOAA Coastal Storm Program 2010).

Tests for toxic contaminants, other than chlorine,[6] have not been conducted in the Salmon Creek Watershed and are not known to be a limiting factor for salmonids or other species. However, because of the potential for even small amounts of pollutants to act synergistically, good stewardship practices should be encouraged to minimize toxin delivery to Salmon Creek and the estuary. Stormwater runoff, swimming pool drainage, improper disposal, and leaking septic systems are likely the primary potential pathways of toxic pollutants into Salmon Creek.

WQ Action 5a: Keep stormwater on site.

Implementation Measures

- Use educational materials, workshops, and demonstration sites to encourage the use of measures such as rainwater catchment, low-impact design, swales, and infiltration ponds to retain stormwater.

WQ Action 5b: Educate community on pollutants of concern and how to reduce water contamination.

Implementation Measures

- Develop and distribute educational materials on websites, at workshops and community events, and on toxic round-up days; see Action 5c.
- Include information on proper use and disposal of household toxics, and safe alternatives.
- Include guidelines for proper drainage of swimming pools and spas.

WQ Action 5c: Promote proper disposal of toxic products.

Implementation Measures

- Hold well-publicized toxics round-up days quarterly to assist landowners with safe disposal of unwanted compounds.

[6] UCCE's analysis of Salmon Creek water quality monitoring data found that, "total chlorine concentrations were greater than the EPA's acute criterion of 0.019 mg/L at 10 sites on the mainstem, estuary, and tributaries on a total of 114 different occasions" (Appendix A). However, UCCE notes that both total and free chlorine readings "are suspected to be inaccurate due to the interference of oxide manganese, which creates the same chemical reaction as a positive chlorine test" and recommends refinement of the testing method.

CHAPTER 6: WATER SUPPLY SUSTAINABILITY ACTION PLAN

Context

Water supplies within the Salmon Creek Watershed must sustain all consumptive water uses, as well as the needs of the wildlife and plant communities. Consumptive water demands are met by the annually recharged shallow groundwater table, bedrock aquifer storage, direct streamflow withdrawals, and the storage of winter rainfall runoff.

The Mediterranean climate and limited groundwater resources produce dry-season water supplies that often cannot meet the demands of both human habitation and wildlife needs concurrently. Salmon Creek, along with much of the coastal range in Marin, Sonoma, and Mendocino Counties, is often considered a water-scarce area (Kleinfelder 2003; Grantham et al. 2010). Groundwater wells and springs commonly experience diminished or intermittent production with regular use and adjacent extraction pressures (Kleinfelder 2003; PCI 2010). Many small coastal communities and residents struggle to maintain adequate, stable water supplies. Water sources adjacent to streams, whether wells or direct instream diversions, tend to provide more reliable supply and are thus preferentially developed and used.

Perennial streamflows are necessary to sustain aquatic ecosystem health and successfully recover salmonid populations. "Water is the most important of all habitat attributes necessary to maintain a viable fishery and … one of the most difficult threats to address effectively." (NMFS 2010). Intermittent flows during the summer rearing period trap salmonids and other aquatic organisms in disconnected pools, subjecting them to increased predation pressures, water quality impairments, and, in some cases, desiccation. When streamflows go subsurface, the cooling and oxygenating effects of water flowing over riffles are lost. High water temperatures and low dissolved oxygen levels in pools can severely stress juvenile salmonids; see Chapter 5. High stress levels lead to reduced feeding behavior, smaller smolts, and, ultimately, poor survivorship.

Low summer baseflows also impact estuary/lagoon habitat conditions. The ratio of freshwater to saline water is critical in determining the viability of the summer lagoon to support estuarine organisms, salmonids, and other special-status species, such as tidewater goby. When freshwater inflows are insufficient to dilute the remnant saline water—delivered prior to the sand bar closing the estuary mouth—stratification of the lagoon water column occurs. Saline water is heavier and thus sinks to the bottom of the lagoon, while the freshwater floats on top. The lower saline

Dry pool in reach of Salmon Creek adjacent to near-channel wells.
Photo courtesy of Lauren Hammack (PCI)

layer, which comprises the majority of the water column, typically becomes heated, anoxic, and inhospitable to fish. This scenario has been documented in the Salmon Creek estuary (PCI 2006), and it limits the viable habitat to a shallow, wind-mixed reach along the sand bar. Restricted habitat due to poor water quality and low streamflows is implicated in the demise of thousands of juvenile steelhead rearing annually in the Salmon Creek lagoon.

National Marine Fisheries Service states in their Public Draft Recovery Plan for Central California Coast coho salmon (2010):

> "Summer baseflow is a critical attribute that is degraded in many streams … [and] a substantial amount of coho salmon habitat has been lost or degraded as a result of water diversions and groundwater extraction (DFG 1997, KRBFTF 1991). The nature of diversions varies from major water developments which can alter the entire hydrologic regime in a river, to small domestic diversions which may only have a localized impact during the summer low-flow period. In some streams the cumulative effect of multiple small legal diversions may be severe. Illegal diversions are also believed to be a problem in some streams within the range of coho salmon (CDFG 2004). The use of wells adjacent to streams is also a significant and growing issue in some parts of the coho salmon range. Extraction of flow from such wells may directly affect the adjacent stream, but is often not subject to the same level of regulatory control as diversion of surface flow."

All water extractions in the watershed likely have an impact on streamflow, some directly and some through indirect cumulative effects. Groundwater sources in the uplands are connected through aquifers, bedrock fractures, and geologic-formation contacts to springs. Springs feed directly into first and second order tributaries, or they locally maintain the water table that sustains summer streamflows. It has been shown that groundwater wells in the alluvial valleys, thought to be disconnected from the water table by an impervious clay layer, can lower the water table and impact streamflows (PCI 2006) and in drought conditions may contribute to localized channel drying.

Riparian pumping and livestock watering directly reduce streamflows. During the summer dry season, particularly during drought years, direct withdrawals may cause riffle disconnection within a reach and, eventually, shallow or dry pools. As described above, multiple extractions reduce overall streamflow and impact instream habitat conditions.

Coastal rural watersheds such as Salmon Creek receive more than enough rainfall to meet the annual water demands of the residents (PCI 2010). However, with a Mediterranean climate, this rainfall comes mainly between the months of November and March. Thus, the water scarcity is seasonal and related to lack of storage. Land-use practices that harden the landscape and route stormwater to drainages limit infiltration, thus reducing the volume of water available to recharge bedrock aquifers and the shallow groundwater that maintains water table levels throughout the dry season.

Opportunities exist to reduce demand on extractive water sources that, through direct or cumulative effects, reduce streamflow and degrade instream habitat. Water conservation and wise-use practices can significantly reduce water demand. Stored rainwater in off-channel ponds and roofwater harvesting systems can easily be used for non-potable irrigation and livestock watering needs. Roofwater can also be used as a potable water source with proper filtration and treatment. Practices to slow and infiltrate stormwater

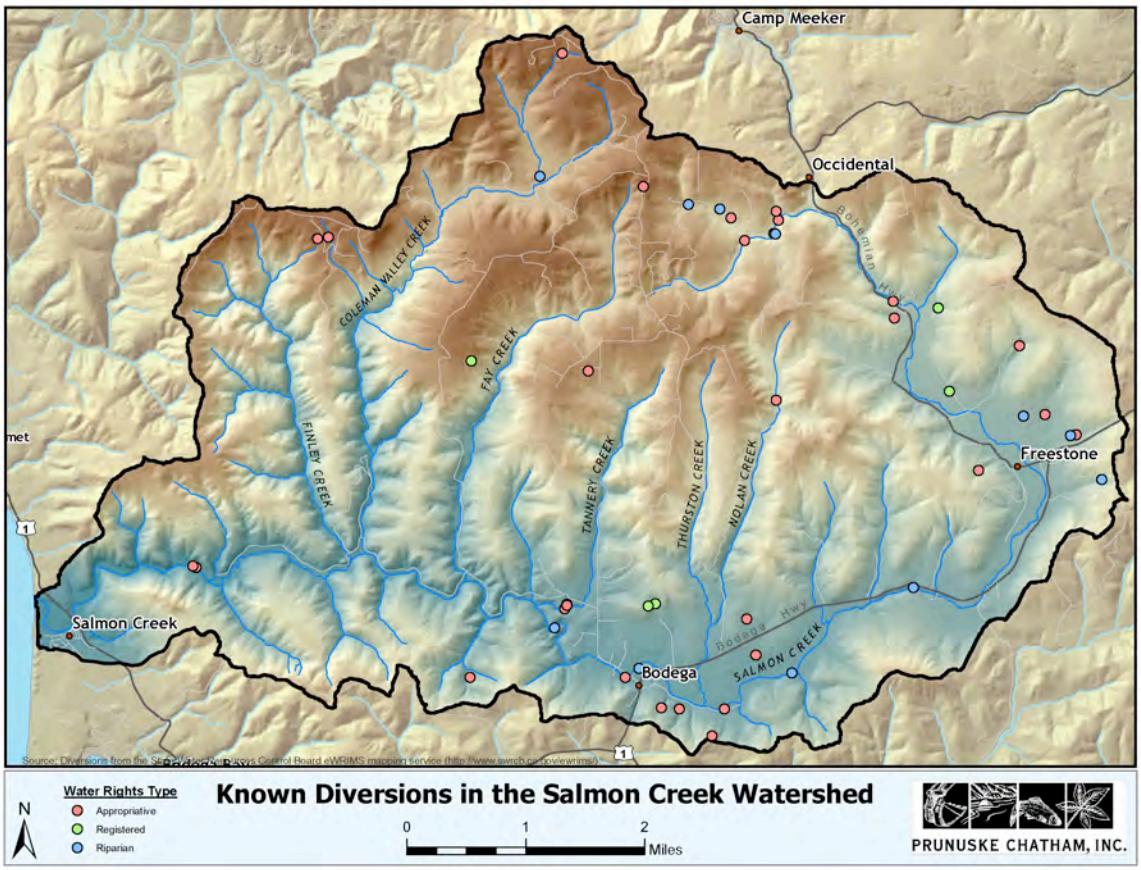
runoff can have long-term impacts on groundwater recharge, spring production, and streamflows.

Concurrent with the development of this Plan, OAEC has spearheaded the Salmon Creek Water Conservation Program with the participation of many partners. The purpose of the program is to support the community in increasing summer instream flows while providing for the freshwater needs of residents. Much of the research and analysis in this chapter is based upon work completed under this program. The program's Salmon Creek Watershed Conservation Plan (PCI et al. 2010) provides detailed conservation strategies and recommendations for residents and community water system operators, and supports the vision and overall goals of this Plan; see Chapter 1.

Goals

- Water demands do not exceed supply.
- Surface water and groundwater supplies within the watershed are managed to support residents' quality of life, family agriculture, and ecosystem needs.
- Extractive water sources and practices that impact summer streamflows are minimized and replaced by alternative water sources or improved storage.
- Streamflows support fish and other aquatic organisms at all lifestages.

Figure 10. Known diversions in the Salmon Creek Watershed.

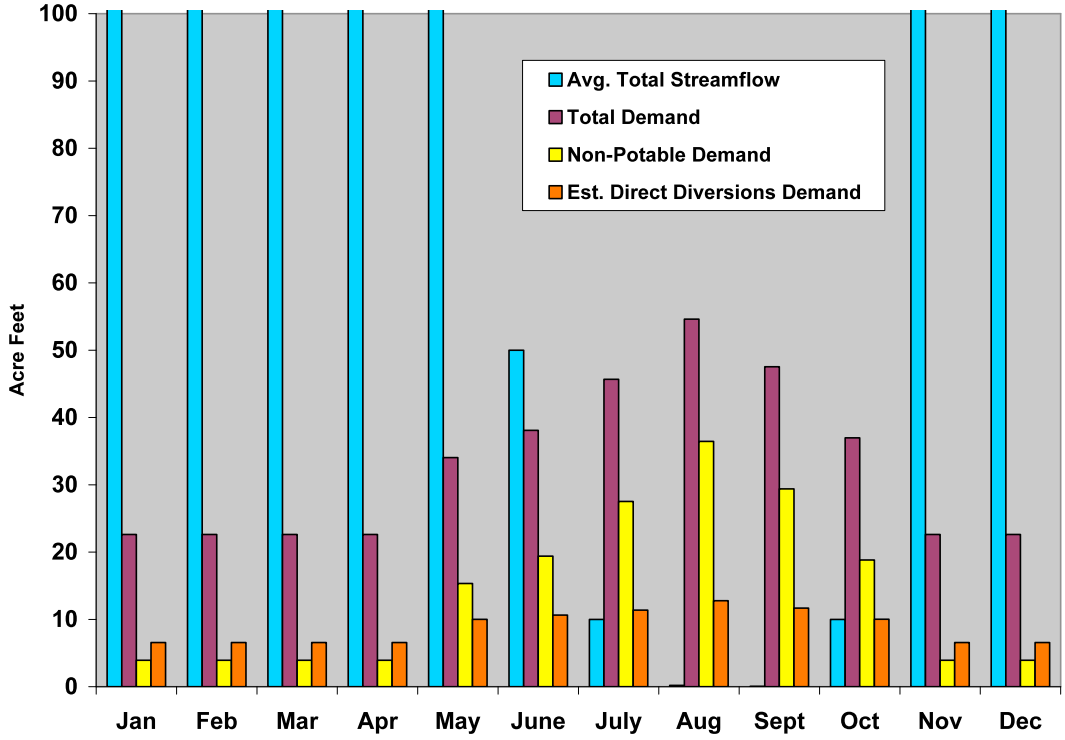


Water Supply Recommendation 1: Develop storage-based water supplies to reduce reliance on, and utilization of, extractive sources.

Scientific Reasoning

Seasonal water scarcity in groundwater and surface water supplies can be offset by storing winter rainfall runoff. Coastal, rural watersheds such as Salmon Creek receive more than enough rainfall to meet the annual water demands of the residents and existing land uses (PCI et al. 2010). Figure 11 illustrates the seasonal cycle of water abundance (winter) and scarcity (summer) as contrasted with the water demand cycles. The seasonal availability disparity can be balanced out—benefiting humans and fish—through the strategic use of storing rainwater in off-channel ponds and roofwater harvesting systems for non-potable irrigation and livestock watering needs. With proper filtration and treatment, roofwater can also be used as a potable water source.

Figure 11. Comparison of water demands in the Salmon Creek Watershed to relative supply, as depicted by streamflow volume.



Source: from PCI et al. 2010.

Estimated late-summer demands on instream sources are 50-200 times greater than streamflow volumes (Figure 11). The direct consumptive uses of instream water in the Salmon Creek Watershed are community water supply wells, livestock watering, summer landscape and garden irrigation, and a small portion of the rural residential use. Capture and storage of winter runoff to replace these direct streamflow withdrawals on a parcel-by-parcel approach could improve instream habitat conditions locally and have significant cumulative effects on summer flows watershed-wide. Replacing all non-potable water demands with stored water would reduce extractive pressures on both the surface water and groundwater supplies and provide greater water security for residents.

Large-scale water storage is not a solution for all water supply concerns and limitations, nor does it mitigate the need for efficient and conservative water use. The impacts of reservoirs on hydrologic flow regimes necessary to maintain ecosystem health have been widely documented (Graff 1999; Richter and Thomas 2007; Grantham et al. 2010). Instream flow regulations for the state of California (AB 2121) are in final draft form and attempt to manage the impacts of water impoundment on streamflow regimes. While it is unlikely that small storage ponds or rainwater catchment systems used to fulfill existing water demands in Salmon Creek would significantly decrease peak runoff during winter storm events, Grantham et al. (2010) suggest that there is an optimal storage capacity for a given watershed that will meet water demands while ensuring critical habitat needs and ecosystem function. Multiple, on-channel storage ponds within a small catchment may reduce early winter base flows and affect salmonid migratory flows.

Water Supply Action 1a: Develop off-channel ponds and distribution systems.

Implementation Measures

- Evaluate agricultural producer's water supply sources to target those using instream or riparian sources.
  - Size systems to cover four (July-Oct.) to six (May-Oct.) months of water demands.
  - Include water distribution systems for livestock use and fence riparian corridors.

Water Supply Action 1b: Install roofwater harvesting systems.

Implementation Measures

- Design and install roofwater catchment systems to replace non-potable water uses from extractive sources and increase water supply security.
  - Size systems to cover four (July-Oct.) to six (May-Oct.) months of water demands.
  - Include water distribution systems for livestock use and fence riparian corridors.
- Consider installing roofwater catchment systems where potable supplies are unreliable, water quality is poor, or water source is a stream diversion.

Water Supply Action 1c: Support landowners in reducing or eliminating use of instream pumps and near-channel wells.

Implementation Measures

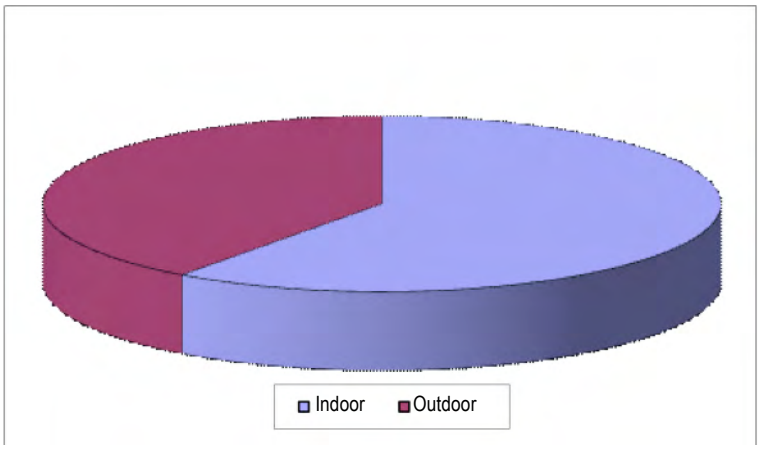
- Conduct an education and outreach program to inform residents of the ecological impacts of using their riparian water rights.
  - Provide alternate solutions to riparian water.
  - Low-flow gardening practices.
- Develop off-channel storage and roofwater harvesting systems to replace riparian water sources; see Water Supply Actions 1a and 1b above.
- Develop program to enroll landowners in abstaining from using their riparian rights for the purpose of salmonid habitat improvements.

Water Supply Recommendation 2: Reduce water demands.

Scientific Reasoning

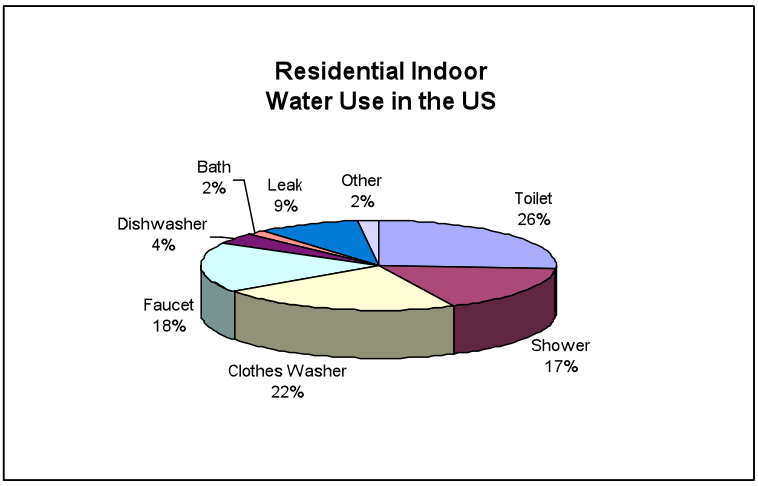
Statewide, the potential exists to reduce residential indoor water use by up to 40% through installing efficient plumbing hardware and adopting practices to maximize water use efficiency and 25-40% in outdoor water use through garden design and maintenance practices (Gleick et al. 2003). Coastal communities and residences fall into the lower portion of these ranges due to climate and water supply constraints. In the Salmon Creek Watershed, it is estimated that a 10-15% reduction in both indoor and outdoor water use could be gained through conservation measures (V. Porter, pers. comm., 4/23/10). Long-term water scarcity issues and increasing water costs have likely pushed residents to implement water conservation measures. Additional water savings may be possible on a site-by-site basis, especially with efficient outdoor irrigation hardware and practices.

It is estimated that 55-65% of all residential water use serves indoor needs in coastal California communities, and outdoor uses make up 35-45% (Pacific Institute 2003). The graph at right illustrates the breakdown of residential water use (PCI et al. 2010).



Actual residential use, or demand, per person (called per capita use) varies according a number of factors, including:

- Age and efficiency of the plumbing fixtures in the home,
- Size of garden, types of plants, climate and efficiency of irrigation,
- Presence of water meters (people use less when water is metered),
- Price of water (people use less when water is costly), and
- Conservation practices used.



A closer look at indoor water use shows that toilets, showers, faucets, and washing machines account for the majority of water use (AWWA 1999); see figure at left (from PCI et al. 2010). The water consumption demand of these devices can be reduced through the installation of low-water use hardware and appliances.

Average nationwide per capita residential indoor water use was measured in a 1999 study (AWWA) to be 73 gallons per person per day. Assuming this represents only 60%

of the residential per capita water use, as discussed above, adding outdoor water use brings the total estimated per capita residential water use to about 120 gallons per person per day. Conservative estimates of Salmon Creek Watershed-specific water demand values align with these nationwide figures (based on an annual demand of 90,000 gallons per residence and 2.06 individual persons per residence; see PCI et al. 2010 for calculation approach and summary). Analyses of meter data from communities within the Salmon Creek Watershed indicate that residences on these systems use 35,000-65,000 gallons per year (47-86 gallons per person per day); however, water costs are relatively high on these systems, and several communities have high numbers of part-time residents (V. Porter in PCI et al. 2010).

Community water systems in the Salmon Creek Watershed have relatively high unaccounted for water (UAW) losses, or the difference between the water produced and water sold (PCI et al. 2010). Water used during routine operational maintenance practices and fire fighting, lost due to leaks, and unaccounted for due to inaccurate meters all comprise UAW. A well-maintained water system should have less than 10% UAW. Freestone and Bodega's UAW are near 30%, which translates to 1,337,800 gallons per year lost. Bodega Bay's UAW averages 14% (PCI et al. 2010). Reducing UAW, especially if it is due to system leaks, and efficiently managing the community water systems will reduce demand on extractive sources (V. Porter in PCI et al. 2010).

Water Supply Action 2a: Implement water conservation program to minimize consumption.

Implementation Measures

- Conduct watershed-wide workshops to educate residents and encourage water conservation practices, such as:
  - Low water use gardening.
  - Water-saving appliances and fixtures.
  - Leak detection and repair.
- Work with County to develop and distribute information on programs that assist landowners in implementing water conservation projects, such as water use audits and Sonoma County Energy Incentive Program (SCEIP).
- Research and develop programs that assist landowners with financial hardships to replace old faucets and appliances with high efficiency devices.

Water Supply Action 2b: Structure water rates to support water conservation and reduce dependence on water supply from sources critical for aquatic habitat.

Implementation Measures

- Address high unaccounted for water losses in community systems.
  - Replace leaking water lines.
  - Replace leaking storage tanks in Bodega.
  - Replace meters regularly.
- Implement conservation rate structure.

Water Supply Recommendation 3: Recharge springs and groundwater.

Scientific Reasoning

In the uplands, along the ridge tops and steep canyons where the rural residential parcels are predominantly clustered, water sources are primarily groundwater wells and springs. However, the dominant geologic formation, Franciscan mélange, is a poor

aquifer with typical yields less than 3 gallons per minute (Kleinfelder 2003). The Franciscan mélange's metamorphic and sheared rocks are impermeable, only carrying and storing water along fracture zones. Wells that tap into a fracture zone will have greater yields. The Wilson Grove sandstone formation, locally capping the mélange, is a better, more consistent aquifer, but it is limited in extent and storage capacity. The springs tend to occur along the boundary between the sandstone and mélange formations (Sonoma County 1974), although they likely also occur where fracture zones in the mélange daylight on canyon slopes.

Groundwater supplies on the ridges are unpredictable. Well production on neighboring parcels ranges from 25 gal/min to not enough to do laundry (pers. comm., 03/2010). Residents in the Joy Road and Willow Creek Road area report that their groundwater wells experience dramatic seasonal changes in production rates. Many have installed holding tanks to compensate for reduced pressure in the summer, while others are forced to truck in water (PCI et al. 2010). Studies of the Joy Road area document that groundwater wells and springs commonly experience diminished or intermittent production with regular use and adjacent extraction pressures (Kleinfelder 2003; Sonoma County 1974). Kleinfelder (2003) also documented that between the 1970s and 2000 the depths of new wells increased to follow a lowering water table and that this trend correlates to development rates and indicates an overdraft condition in the aquifer.

Managing stormwater runoff in uplands in ways that slow flow overland, temporarily detain it, and allow it to infiltrate into the ground can increase groundwater recharge. The benefits of increasing aquifer recharge rates and storage capacity are greater groundwater supplies and increased stream base flows. Other benefits of keeping stormwater on site, instead of the historic "pave it and pipe it" approach, are decreased topsoil loss, lower flood peaks downstream, and reduced pollutants in the water.

Water Supply Action 3a: Increase infiltration in upland recharge areas and up-gradient from springs.

Implementation Measures

- Install rain gardens to capture excess runoff.
- Install contour infiltration trenches and infiltration swales to temporarily hold and infiltrate runoff.
- Direct excess runoff into catchment basins that store and allow slow infiltration.
- Replace impervious surfaces, such as parking areas and patios, with pervious materials (grass pavers, porous concrete, and other pervious pavers).
- Effectively manage grasslands and forests; see Chapter 3 Uplands Management Action Plan.

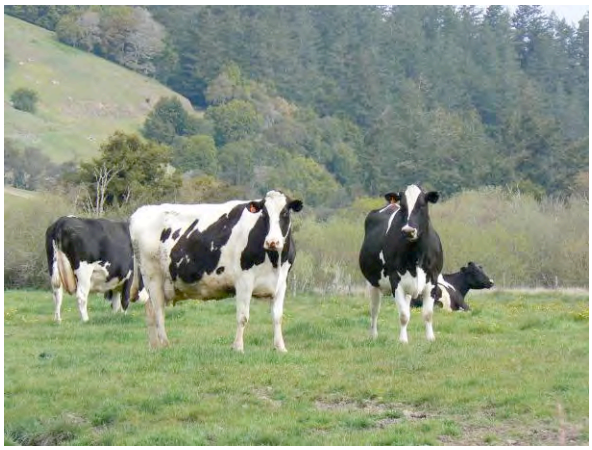
Water Supply Action 3b:Reduce stormwater runoff in uplands.

Implementation Measures

See Chapters 3: Uplands Management Action Plan and 5: Water Quality Management Action Plan.

CHAPTER 7: SUSTAINABLE AGRICULTURE ACTION PLAN

Context



Agriculture in the U.S. has changed dramatically over the past fifty years as post-war technologies for fertilizer production, chemical use, plant genetics, petroleum extraction, and mechanization were applied to farming. These practices proved to be essential developments in providing a stable food supply for the ever growing world population suffering from the repercussions of global turmoil. In what was heralded as "the Green Revolution" of the 1950s and 1960s, agricultural productivity skyrocketed, allowing impoverished countries to greatly improve food security and developed nations to reduce farm labor needs and food costs (Griffin 1979). Agriculture became greatly centralized, with the U.S. farm population shrinking from over 12% in 1950 to less than 2% today (Heller and Keoleian 2000). Prices of staple commodities plummeted, allowing Americans to spend a smaller percentage of their annual incomes on sustenance than any population in the world (USDA 2006). While the benefits of a prolific, dependable food supply are inarguable, these efficiencies in agricultural production have come with a price.

Globally, highly mechanized and chemically dependent farming has led to a multitude of environmental problems, including topsoil erosion and depletion, water quality concerns, pesticide contamination, and loss of biodiversity. Centralized production and processing systems have resulted in most food products travelling an average of 1,500 miles to reach consumers, which has had enormous repercussions for air quality, dependency on foreign oil, and climate change from greenhouse gas emissions (Pirog and Van Pelt 2002). From a human health perspective, while mass quantities of lower-value staples such as corn and soybeans have provided needed surpluses for disadvantaged populations, their overproduction has led producers to develop these goods into value-added products of minimal nutritional value, such as corn chips and soft drinks, a trend that has had unquestionable effects on obesity rates and other health indicators in the U.S. and throughout the world (Wallinga 2010). Loss of production diversity of both plants and farm animals has led to widespread use of fertilizers, pesticides, antibiotics, and other chemicals that have entered the food supply and waterways. Centralized agribusiness production has also had social consequences by removing communities from their food production and threatening family farming traditions and incomes, as well as the widely cherished rural lifestyles and landscapes. Many rural areas, once self-sustaining and productive, have been pushed out of the agricultural markets by the artificially low prices of subsidized mass production and have been left with few economic options (Feenstra, undated).

Such consequences have led to a growing interest in more localized and sustainable alternatives over the past two decades as consumers have begun to recognize the role their buying power can play in addressing the environmental, social, and economic concerns related to food. The concept of sustainable agriculture has continually evolved, growing to include multiple environmental, social, and economic considerations, and

becoming integrated into a variety of certification vernacular such as "organic," "humane-raised," or "fish-friendly"® (Marcus 2009).

Sustainability in agriculture was more officially defined by the U.S. Congress in the 1990 Farm Bill, which characterized it as "an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- Satisfy human food and fiber needs;
- Enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- Sustain the economic viability of farm operations; and
- Enhance the quality of life for farmers and society as a whole."

The definition describes a broad-scale, integrated approach that provides roles and benefits for the producer, consumer, and community and necessitates involvement from policy makers, researchers, landowners, farm workers, retailers, and others.

Components of Sustainable Agriculture
While the word "sustainable" has in recent years become synonymous with ecological concerns, its true definition must equally consider social and economic aspects. Some considerations related to each of these three primary components of sustainability are described below.

Environmental considerations:
Soil quality. Soil health involves both quality of the soil itself as a living medium and structural stability provided by its supported vegetation. It can be degraded through erosion, compaction, loss of soil biota through pesticide use, and depletion of soil organic matter.

Water use. Water remains a primary concern in California's Mediterranean climate, which is characterized by cool, wet winters and hot, dry summers. While much of the state's agriculture relies on a complex system of water storage and transfer from reservoirs, aquifers, and the Sierra snowpack, coastal areas enjoy cooler temperatures and relatively higher annual precipitation than inland regions. However, rainfall patterns on the coast continue to pose complications for farmers and ranchers who face water quality concerns from runoff and erosion during the winter months and limited water supplies in the summer. Production systems need to be appropriate to local availability and to practice water conservation and recycling. Always deeply political, water use issues in northern coastal California have been brought to the forefront with the devastating crash of the Pacific Northwest's already dwindling salmon populations, which serve as the backbone of the region's fishing industry, valued at over $130 million per year, and a way of life for coastal Native American communities.

Water quality. Connected to water use issues is water quality, a concept that considers numerous conditions, including temperature, sedimentation levels, nutrient levels, salinity, pH, dissolved oxygen levels, and levels of contaminants, such as pesticide residues or heavy metals. Water quality is essential for maintaining aquatic life and providing safe drinking water for people, livestock, and wildlife. Sustainable farming systems consider on-farm nutrient and sediment retention and protection of riparian areas.

Air quality. Numerous aspects of agricultural production can have implications for air quality, including carbon and nitrous oxide emissions from fuel and fertilizer use, dust, pesticide drift, and burning of crop residues. The role of agriculture in global climate change is considerable, both in its contributions to carbon emissions and its potential for sequestration through plant CO_2 uptake and preservation of vegetated land.

Energy use. Most modern agriculture is heavily dependent on non-renewable fossil fuels for production, transportation, and processing, totaling over 10% of the energy use in the U.S. An estimated 40% of this is used to create and transport chemical inputs, such as pesticides and inorganic fertilizers (Heller and Keoleian 2000), which has enormous implications for climate change and economic stability. Efforts to reduce fossil fuel use could include minimal-till farming, localized production and processing, reduction in energy-heavy chemical inputs, and fuel alternatives.

Habitat and biodiversity. Conversion of natural areas to modern agricultural production has traditionally removed native habitat and displaced wildlife, while threatening neighboring preserved areas through erosion into waterways, pesticide use, and corridor removal. However, in keeping large tracts of land from development, well-managed agricultural systems can actually provide wildlife habitat and maintain migration corridors.

Agrobiodiversity. Modern agriculture has resulted in loss of diversity in farm production with the economies of scale and specialization favoring monoculture crops and removal of on-farm natural or semi-natural areas, such as hedgerows or wetlands. While initially increasing productivity, this trend has made farms more susceptible to market fluctuations, pest problems, and soil nutrient depletion. These problems have, in turn, created heavy reliance on subsidies, pesticides, and nutrient inputs. Sustainable systems mitigate for these concerns by creating diversity both on-farm and across landscapes.

Social considerations:

Human health and well-being. While modern agriculture has greatly increased overall food availability for much of the world's population, it has had other repercussions on human health and overall well-being. Surpluses of corn, soybeans, and other staples have led the marketing of value-added "junk food" products, while pathogens and contaminants from antibiotics, pesticides, fertilizers, and other chemical inputs have appeared in food and water. Farm worker health and quality of life have also emerged as major concerns, particularly in California, where many immigrant farmhands operate outside of legal protections.

Beekeeping is fast becoming an important part of pollinator-based agriculture.

Animal welfare. The vast majority of modern meat and dairy production involves confined animal operations or "factory farms," in which large numbers of animals are often restricted to very small areas where they can be subject to immobilization, stress, disease, and inhumane slaughter practices (Pew Commission 2008). Recent efforts have been taken to incorporate animal welfare standards into certification programs, including the American Humane

Association "Free Farmed" label and the Humane Farm Animal Care's ISO-certified label "Certified Humane Raised and Handled."

Preservation of farmland and farming traditions. While farming was once the mainstay of the American economy and identity, fewer and fewer families have maintained these traditions, with less than 2% of the U.S. population now actively producing food. Rising land values have led many farming families to sell productive land for conversion to housing and suburban development, resulting in the loss of over 3o million acres of farmland since 1970.

Community connection to food production. Most Americans are completely removed from food production systems and have retained little understanding of the issues involved, which has had enormous implications for farmers who remain subject to political measures surrounding land use, subsidies, and regulatory efforts. This lack of involvement also keeps consumers from recognizing the influence of their purchasing power in supporting agriculture.

Economic considerations:

Financial viability of farming operations. As food production has become more and more concentrated into large-scale agribusinesses, family farms have become increasingly untenable financially, and many families have been forced to sell generations-old land to conglomerates or developers. While agricultural sustainability by nature begins with the producer, the burden of its implementation cannot rest solely on the small minority of farmers. A key consideration for communities seeking sustainability in agricultural production is to recognize the process involved and to support local producers as they work to attain it. Many transitional steps are time-consuming and expensive to implement, such as organic certification or the infrastructure development to reduce nutrient runoff, and farmers require financial, technical, and regulatory support throughout the process.

An affordable food supply. Americans currently spend a smaller percentage on food than any civilization in recorded history, with estimates ranging from 9-12% (Gallo 2008). As the hidden costs of this production have begun to emerge, such as fossil fuel and chemical input uses, many have started turning to more sustainable alternatives. The organic food market has grown more quickly than any other agricultural sector, at a rate of nearly 20% annually, despite the higher purchase price of organic food. The challenge for sustainable agriculture will be to ensure food remains affordable while addressing ecological or social concerns.

Rural community development. The loss of small farms has led to a disintegration of local production and marketing structures and a general shift in rural community development away from food production. Rural communities throughout California have been faced with economic losses and greater reliance on urban industries.

Sustainable Agriculture in the Salmon Creek Watershed.

Although Sonoma County remains one of the most productive farm counties in California, ranking 16th in the state and 34th in the nation, farmers throughout the County continue to struggle to keep their operations viable. According to the County's General Plan, "except for vineyards, other agricultural commodities generally do not generate sufficient profit to justify agricultural land prices in the County," forcing local farmers to "rely more on specialty niche markets and creative marketing to be competitive." (PRMD 2008a).

Several producers within the Salmon Creek Watershed have capitalized on niche market opportunities, producing high-value products, such as high-quality wine grapes, goat cheese, free-range or grass-fed meats, and organic milk. Two such producers, Kurt Beitler and Patty Karlin, are profiled below, along with the more conventional production system of rancher Walt Ryan. Efforts such as these have allowed the watershed to retain its rural character and its large, undeveloped parcels, which have, in turn, preserved essential ecological functions, such as wildlife habitat and air quality. A discussion of niche marketing, written by Gold Ridge RCD District Manager and Salmon Creek rancher Joe Pozzi, is also included.

A large component of these niche markets is the certified organic sector. California currently serves as the leading producer of organic commodities, a market growing by 15-20% annually over the last ten years (Sierra et al. 2008). A primary contributor to this movement, Sonoma County had nearly 16,000 acres in organic crop production in 2007 (not including land used for organic meat and dairy) and has been the birthplace of several certification programs focusing on sustainability, such as the "Fish-Friendly Farming" label for wineries or Clover-Stornetta's North Coast Excellence seal for milk production (Sonoma County Agricultural Commissioners Office 2008; Marcus 2009). Working in tandem with niche production, localized food processing has proven to be a growing sector of Sonoma County's economy, with employment increasing by 15% between 1997 and 1999 alone. In response to increased local demand, nearly half of these processors were producing certified organic products by 2002 (Sonoma County Economic Development Board 2002).

Residents of Sonoma County have repeatedly shown strong support for preserving local family farming traditions, voting to fund agricultural land preservation and attending over a dozen popular farmers' markets throughout the County. Multiple objectives laid out in the County's General Plan relate directly to agricultural preservation and sustainability, with the stated goal "to ensure the stability and productivity of the County's agricultural lands and industries" (PRMD 2008a). These include assistance with marketing and promotion of agricultural products, protection of farmland from urban encroachment, and the development of agricultural support services. A second section addresses the goal "to preserve the unique rural and natural character" of the County and "protect and enhance the County's natural habitats and diverse plant and animal communities," riparian corridors, soils, and forestry resources.

Goals

- The Salmon Creek Watershed supports a healthy, competitive, and sustainable agricultural industry.
- Large agricultural parcels are left intact to provide open space, support wildlife habitat, and preserve the watershed's rural character.
- The landowners in the watershed have the financial and technical support necessary so that agriculture continues to conserve or enhance the natural resources.

Sustainable Agriculture Recommendation 1: Facilitate opportunities for producers to locally process and market agricultural products.

Scientific Reasoning

Consumers throughout the Bay Area have shown a growing willingness to pay premium prices for local, sustainably produced products. One example of this trend is the expanding market for grass-fed beef. With prices nearly double that of conventionally produced beef, grass-fed beef has appealed to consumer interest in not only enhanced health benefits, but also in its implications for animal welfare and open space preservation.

Recent market studies from U.C. Davis have shown that the most sensitive consideration in operational costs for grass-fed beef production is shipping, primarily the location of both processing plants and target markets (Harper et al. 1996). This finding has considerable implications for the localized beef industry of Sonoma County, which is facing possible closure of the nearby Rancho Veal processing plant in Petaluma, the last cattle processing plant in the North Bay (Petaluma Argus-Courier 2006). While communities have provided support for local produce production in the area through Community Support Agriculture (CSA) programs and farmers' markets, meat marketing has proved more difficult due to lack of processing options.

Sonoma Direct, a local meat company with processing and distribution capacity, is working in partnership with UCCE to launch a locally focused Meat Buying Club that seeks to connect local ranchers more directly with consumers. The program focuses on grass-fed, family-farmed meats produced without hormones or antibiotics and using practices conducive to humane treatment of livestock and environmental stewardship.

Another distributor linking local producers with the community is Field to Family Natural Foods, begun in 2004 by Wayne and Amy Dufond. Field to Family provides poultry, beef, and pork products to area grocery stores, ensuring products from animals raised in humane, free-range conditions with vegetarian diets and without antibiotics or growth hormones. Their products include Beeler's Naturally Pure Pork, Panorama Grass Fed Beef, and Air Chilled poultry products, and lambs grown in the Salmon Creek Watershed. Efforts such as these can be supported and expanded to allow greater participation among local producers.

Action 1a: Promote and sustain agriculture-related industries in or near the watershed and develop forums for linking them with producers.

Implementation Measures

- Seek funding to support establishment of businesses that provide services, such as processing, storage, bottling, canning, and packaging.
- Address regulatory hurdles to on-farm livestock processing or "mobile slaughterhouses."

Action 1b: Develop a watershed "brand" synonymous with locally produced, sustainable, high-quality farm products.

Implementation Measures

- Work with public outreach organizations to promote public appreciation for local agriculture.
- Develop educational opportunities to teach producers about marketing strategies and business management.

- Assist in the development of effective distribution channels for locally produced goods.
- Assist farmers in developing value-added marketing plans for their products while establishing an overall market presence for the watershed as its own appellation.

Sustainable Agriculture Recommendation 2: Preserve open space and rural landscapes by keeping large agricultural parcels intact and their operations viable.

Scientific Reasoning

Large parcels provide valuable wildlife habitat and open space, while contributing to the watershed's rural character. Agricultural landowners need to be supported to sustain viable operations in order to maintain these large parcels. While updated zoning laws prohibit subdivision in some areas, the affected landowners are struggling to maintain financially viable operations to preserve these working landscapes.

Action 2a: Support producers in diversifying income and seeking financial assistance.

Implementation Measures

- Assist producers to participate in programs that provide additional capital to support agricultural land values, such as conservation easements through the Williamson Act.
- Coordinate with NRCS staff to assist producers in developing Farm Bill program contracts.
- Work with agricultural landowners to explore other farm-related income options, such as farm tours.

Sustainable Agriculture Recommendation 3: Ensure sustainable resource use in agricultural production.

Scientific Reasoning

The Salmon Creek Watershed has sustainably supported agricultural operations since its early settlement. It is actually the loss of agricultural land to residential development that poses the most risk of depleting groundwater supplies and transforming the valued pastoral landscape. However, some aspects of agricultural production itself do merit concerns about resource protection.

Vineyard development poses the greatest concern for agricultural water use within the watershed. Currently, many locally owned Salmon Creek vineyards are dry-farmed. Most are also zoned only above the frostline, eliminating the need for frost protection, which uses water when stream flows are low. However, some vineyards in the area are managed by outside companies, who often don't have a good understanding of local water use issues. Vineyard establishment also requires high water use for several years, making rapid expansion of vineyards a concern. Since this area is predominately dry-farmed, the importance of added economic value vineyards bring to a landowner's viability is important.

Water quality serves as the biggest concern for livestock operations, particularly dairies. Concentrated livestock on dairies produces large nutrient and pathogen loads, threatening aquatic life. Confined animal facilities throughout the Bodega Bay

Hydrological Unit have been identified as sources of nutrient and sediment runoff into the Bodega Bay by the Regional Water Quality Control Board.

Vegetated buffers and intact riparian corridors can serve as effective ways to greatly reduce contamination of water sources from sedimentation, nutrients, and pathogens, while simultaneously maintaining riparian corridors for wildlife and stream shading needed for salmon survival. A U.C. Davis study has shown that 99.9% of pathogens are trapped within one yard of their source, indicating that buffers do not have to remove extensive stretches of land from range to reduce water contamination (Tate et al. 2006). Properly constructed wetlands can also be used to filter pasture runoff through anaerobic denitrification of trapped sediment.

One recent legislative change that may greatly affect the operations of Salmon Creek's two remaining dairies is USDA federal regulations passed in October 2008 governing organic dairying. Meant to target large-scale operators running confined animal-feeding operations with no pasture access, the new regulations state that dairy operators must now keep cows in open pastures during the "growing season." In coastal areas, this may coincide with heavy rains, a requirement that may not be appropriate for rainy coastal areas where fields become overly muddy. Pasturing cows through the winter could have severe repercussions for water quality, forage production, and animal health (Digitale 2008).

Action 3a: Work with vineyard operators to reduce water use.

Implementation Measures

- Provide workshops and technical support for vineyard dry-farming.
- Assist vineyard operators in acquiring support through NRCS and RCD programs to develop water conservation measures.
- Work with vineyard operators to understand and remain a step ahead of groundwater regulation measures as they develop.
- Educate the local community on vineyard practices.

Action 3b: Assist rangeland and dairy operators in implementing water quality protection measures.

Implementation Measures

- Provide workshops and technical support for dairy and rangeland operators to assist in compliance with water-quality regulations.
- Assist rangeland and dairy operators in acquiring assistance through NRCS and RCD programs to protect riparian areas.

Action 3c: Assist livestock operators to develop and implement nutrient management plans.

Implementation Measures

- Implement a proactive, on-farm nutrient management program that will include a "user-friendly" nutrient budgeting model, soil, vegetation, and manure sampling protocols, and a land application tracking system. The program will assist watershed dairy and livestock operators with the ability to write nutrient management plans based on facility inventories and nutrient budgeting information.
- Secure funding to effectively develop nutrient management or conservation plans for all livestock operators.

- Provide technical assistance to dairy and livestock operators to conduct on-farm facilities inventories and nutrient budgeting.
- Conduct, soil, vegetation, and manure sampling to identify the proper organic fertilizer application rates for farm fields.
- Complete nutrient management plans and land application tracking systems.
- Use buffer strips to trap sediment from confined animal and other high-use areas.
- Work with interested landowners to develop waste-to-profit systems, such as methane digesters and on-site fertigation equipment that spreads manure onto forage fields.

Landowner Profiles

Joe Pozzi – Creating the Salmon Creek Watershed "Brand"

For many years, agricultural producers in the Salmon Creek Watershed had little involvement with marketing: once the product left the farm gate, it was somebody else's problem. The commodities produced here were quickly consolidated into larger groups of products from all over the country and world. We had no identity as to who we were or what we produced. The small farmers in the watershed were quickly shut out of these large markets, unable to achieve the economies of scale of large agribusinesses in other areas.

However, a significant change has occurred over the past ten years. Many modern consumers, particularly in the Bay Area, want to know where and how their food and fiber are produced and are seeking organic, humanely raised, or other indications these products have been produced sustainably. With rising concerns about global climate change, there is a heightened scrutiny of the carbon footprint of food production. These evolving consumer concerns have caused farmers and ranchers to become more involved with the public interface, a whole new shift in paradigm for many local producers. Not only do we need to be efficient in producing a wholesome, safe product and be good stewards of the land, we now also need to be the marketing arm of our businesses.

While daunting for some producers, this revelation is actually a silver lining for others, because we are now able to represent our products for what they really are. Now, in a trend reminiscent of the watershed's agricultural history, there is milk going to local organic creameries, and goats producing cheese marketed throughout the Bay Area. The lambs produced in the watershed are marketed as a specialty product in many restaurants and stores; the wool is used in organic bedding products sold both locally and throughout the United States. The dry-farmed vineyards are family owned and keep a large number of local people employed. The cattle are being marketed as grass-fed beef, and many are identified as to where they were raised and how they were taken care of.

The most important aspect of this process is that the producer has an opportunity to add value to his or her product through this interaction with the consumer. We all have an

interesting story as to what we produce and why. The consumers of today want to hear that story, so you now see ranchers carrying business cards and developing websites. You will see their products at farmers' markets or on a brochure at an upscale restaurant or food store. This trend has helped get our products recognized by the surrounding consumers and has put the producer in a position to be a price giver instead of a price taker, to create markets rather than being shut out of them.

I think we will continue to see an expansion into niche and value-added products being produced within the Salmon Creek Watershed. While it can be successful and profitable, niche marketing is not easy. There is a tremendous amount of work getting the product to the farm gate, and there is just as much work in getting it to the consumer. The value of the product has to reflect the time put into it by the farmer for his or her business to succeed and for the farming traditions and landscapes of the Salmon Creek Watershed to be preserved.

Kurt Beitler, 2010

Kurt Beitler (Viticulture)

Kurt manages several vineyard properties along Taylor Lane, the top of the Tannery Creek Subwatershed, including a 10-acre area producing high-value pinot noir grapes for prestigious Napa Valley's Belle Glos label, a winery built by Kurt's grandfather. Other properties provide grapes for Caymus Winery cabernets and Kurt's own Bohème label. Since he began managing the property in 2000, Kurt has introduced many innovative practices to the operation. While most vineyards in the area use conventional vertical shoot position (VSP) trellises, with fruiting vines growing vertically at hip height, Kurt's family has converted their vines to an overhead pergola system. This allows the fruiting vines to grow horizontally overhead, which adapts the plants to the region's more limited sunlight by maximizing sun exposure. The system has the added advantage of producing fruit 5 to 6 feet off the ground, allowing Kurt to use sheep for weed control. The system has proven effective in producing high-quality grapes, allowing for early high-sugar levels from the added sun exposure. Productivity ranges from 0.5 tons/acre in a poor year to 2.5 tons/acre, standard levels for the watershed, which produces low-volume, high-quality grapes. Belle Glos wines are generally marketed for $60-$70 per bottle.

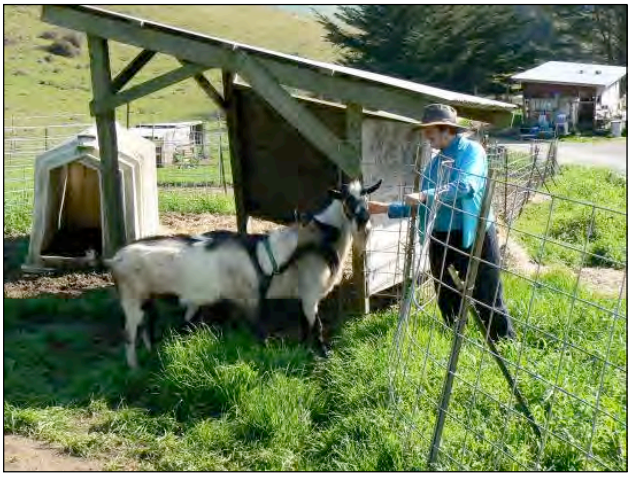
A flock of 25 sheep currently graze the vineyard year-round, eliminating the need for strip-spraying, which is normally required to lessen weed competition between vines out of reach of a mower. Grazing also greatly decreases mowing requirements, saving labor and fuel costs and reducing fossil fuel use and greenhouse gas emissions. The sheep themselves require minimal expenses, including some supplemental feed,

veterinary care, and sheering, along with reinforcements to the irrigation system to protect it from grazing damage. Kurt has given the wool to local spinners and has occasionally harvested lambs for personal consumption.

Neighboring landowners have expressed approval of these management techniques, appreciating the multi-use production system and minimal chemical use. Sensitive to neighbors' concerns about water availability, Kurt has also worked to minimize water use, beginning with the use of a local drought-tolerant rootstock. The vineyard is dry-farmed when possible, and any irrigation water comes from an on-site rainwater catchment pond rather than being pulled from overstressed groundwater sources. Most importantly, Kurt emphasizes the importance of on-site management, which allows him to respond appropriately to local conditions and develop a more sustainable production system. (Beitler, K, pers.comm., 2010)

Patty Karlin (Bodega Goat Ranch)

Known throughout western Sonoma County for her goat cheese, Patty owns and manages a diverse operation at the ranch, which sits on over 7 acres up Tannery Creek Road. While the 60 Alpine goats and on site creamery serve as the basis for the operation, Patty promotes a system of cooperative farming in which she works with other producers to keep ducks, guinea hens, turkeys, chickens, and pigs. She plans to soon add beekeeping to the mix to provide hives to area growers requiring pollination services. The livestock diversity holds several advantages, from fertilizer production, whey disposal as pig feed, and weed control as different species can be used to target different weeds. The creamery is also rented to other cheesemakers.



Patty Karlin and her goats, 2010.

To promote biodiversity and forage, Patty has created permaculture swales planted with tree and shrub species as goat browse. Goats are natural browsers, relying on high-protein leguminous shrubs for milk production. While they can and do eat grasses, they can't digest them as effectively, which results in lost productivity, higher methane production, and land needs beyond the ranch's acreage, which would require Patty to purchase supplemental feed. The ranch also has a medicinal garden that supplements the goat feed, which has greatly reduced veterinary costs. Pastures are seeded with selected native grass species, a practice that works both to increase the forage value of the pastures and to enhance the conservation value of the land.

To address the area's low water availability, a complex system of roof water catchments, ponds, and swales were constructed that allow for 90,000 gallons of water storage and supply all of the ranch's water needs. The ranch has also been equipped with commercial-sized solar panels to serve the residences and the creamery, an investment that recouped its own installation costs within 4 years.

The goat cheese is marketed primarily through local farmers' markets, small localized distributors, and area restaurants. Selling a product that can be vacuum-packed or aged also allows Patty to spread her income out throughout the year, selling cheese even during the goats' gestation period in the winter.

While she currently handles all aspects of the operation, Patty is working with FarmLink to have interns take over the fresh cheese production in order for her to assume a more mentoring role. This has proven to be quite a daunting task, with the ranch producing 150 pounds of cheese a week for 8 months each year. In providing internships, hosting agro-tourism tours, and participating in conferences and workshops throughout the world, Patty's vision is to have the Bodega Goat Ranch serve as a model of agricultural sustainability (Carlin, P., pers.comm., 2010).

Walt Ryan (Cattle Ranching)

Walt Ryan's ranch has been in his family for 120 years, since it was purchased by his great-great-grandfather for timber production, and later converted to a grade-B dairy with a small sheep flock. The property was converted to beef cattle rangeland in the 1960s, as small dairies had become financially unviable due to the collapse of the wool market and predation by coyotes. Walt's ranch currently supports cow-calf pairs, and a handful of sheep used to graze around the house for fire protection. While many ranchers in the area calve in the fall, Walt changed the calving regime to the spring so the cows no longer require supplemental feed. While the property's topography make fence installation for rotational grazing challenging, Walt works to ensure grassland health and good use of forage by moving salt supplements, monitoring water sources, and keeping stocking rates at sustainable levels.

With children looking to take over the ranch, Walt has struggled to maintain the viability of his operation, given increasingly strict regulations and zoning constraints. With nearly two-thirds of his ranch covered in valuable hardwoods, redwoods, and Douglas-fir, Walt sees managed timber harvesting as an option for diversification, but has been discouraged from attempting to pursue the option due to the laborious regulatory procedures required. Zoning specifications stemming from the area's limited water supply has restricted subdivision possibilities, and predation continues to limit sheep ranching in the region. Climate and water availability on this coastal property has also limited the possibility of vineyard development. Vertically integrating his cattle operation has also proved infeasible, due to the restrictions placed on on-farm processing. And while grass-fed beef has proved to be a value-added product for some area producers, the steps required to enter that market structure are too often not deemed economical for many ranchers, particularly those with limited marketing experience.

As with all farming families, the Ryans have struggled with the California tax structure, under which it's become more and more difficult for producers to keep their land in agriculture from one generation to the next due to soaring land values and increasing inheritance taxes. Though determined to maintain his families ranching traditions, Walt has even explored other non-agricultural land uses, and has leased the property to hunting clubs and wedding parties, and even looked into establishing conservation easements. However, these uses give rise to obvious privacy and liability concerns, while providing limited income and, of course, no food production.

While continually struggling with regulatory pressures, Walt sees the root issue to be the disintegration of the community's connection to the land. Sonoma County's growing population often supports regulations and political measures that make farming more

and more difficult, without putting into place the necessary support structures to help farmers remain in compliance. With a smaller and smaller percentage directly involved in the industry, many Sonoma County residents fail to recognize the constraints and realities of food production.

Despite the ever-increasing difficulties faced by ranching families in the watershed, Walt has worked tirelessly to push these realities to the forefront. He currently serves as a director on the boards of the Sotoyome Resource Conservation District and the Sonoma County Farm Bureau. He also sits on the advisory board of the Santa Rosa High School Agricultural Department, which works to introduce a new generation to vocational opportunities within agriculture by involving students in the management of an onsite farming operation.

CHAPTER 8: IMPLEMENTATION

This chapter provides a framework to bring the Plan's recommendations into existence. An intention of this Plan is to recommend land management practices that will directly contribute to water pollutant load reductions and hydrologic condition improvement. The first section of this chapter summarizes our current understanding of known pollutants in the watershed and the relative level of load reduction expected from the recommended management practices.

Chapter 8 then goes on to identify who would implement actions by when and addresses the value of partnerships to engage watershed residents and support Gold Ridge RCD in meeting watershed goals. It presents an overall strategy for keeping watershed residents and other stakeholders current with new information and management practices. Finally, the chapter identifies potential funding sources and provides a brief summary of permits that may be needed for implementation.

Pollutant Load Reduction and Success Criteria

Chapters 3 through 7 outline information related to, and actions designed to improve, the overall health and functioning of the watershed for wildlife and human residents. Chapters 4, 5, and 6 focus on riparian and instream habitat conditions, water quality, and water supply availability, respectively. These three chapters summarize baseline data for habitat conditions and pollutant factors and indicate where and when conditions have deviated from indicator target values.

Water-quality and streamflow monitoring efforts to date have not been designed to directly estimate pollutant loading. Results from the baseline water-quality monitoring program were not sufficiently statistically robust to estimate pollutant loads (UCCE 2009, Appendix B). Load estimating using watershed models is an altrnative approach. However, for the model results to be accurate, the input data must be correlated to site-specific information and the output checked for accuracy against real data. This type of modeling approach, with its associated data collection and computational needs, was beyond the scope of this Plan. Loading rates based on published literature, while commonly used, are too general to provide a much higher level of precision than local, knowledgeable professional judgment in designing and ranking load reduction measures in the watershed; see Table 6 below. The misapplication of published literature loading values or inaccurate model results may lead to unintended consequences for landowners and resource agencies. Therefore, we have chosen to characterize pollutant load reduction in a qualitative manner that rates their potential to effect changes in indicators.

As illustrated in the Table 6 below, a single land-use management practice may affect multiple hydrologic and pollutant factors. Successful reduction of any pollutant load or improvement in a hydrologic condition requires implementation of multiple management practices. Project development and prioritization will need to include evaluation of the potential to reduce pollutant loads or improve hydrologic conditions within a reach or watershed wide.

Table 6. Potential for land management practices to reduce pollutant loads in the Salmon Creek Watershed.
High potential (H), medium potential (M), and low potential (L) are relative and subjective. Additional data collection and watershed modeling are necessary to substantiate and quantify pollutant loads and expected reduction amounts.

Evaluation of Pollutant Load Reduction Measures									
	Hydrologic Factors			Pollutant Factors					
Management Practices	Dry-season flows	Infiltration/ Groundwater recharge	Flood peaks/ Flashiness	Turbidity	Temperature	Dissolved oxygen	Nutrients	Pathogens	Toxins/ Heavy metals
Manage forests for fire safety, diversity, and health		H	M	M					
Manage grasslands for species diversity and health		H	M	M			M	M	
Stabilize upland gullies				H					
Improve or decommission rural roads				H					
Install sediment retention basins		M	M	H			L	L	
Construct vegetated infiltration bioswales		H	H	M			L	L	
Disconnect impervious surfaces and drainage ditches from waterways		M	H	H			M	M	H
Promote use of pervious materials		M	M	L					
Upgrade septic systems						M	H	H	M
Reduce use of pesticides and fertilizers							M		
Install riparian fencing to limit livestock access	H			M		H	H	H	
Implement agricultural nutrient management				M		M	H	H	
Increase riparian buffer width	L		L	M	H		H	M	
Plant riparian trees					H	H	L		
Stabilize eroding streambanks with bioengineered solutions				L	M				
Implement rainwater harvesting and storage projects	H	M	L		L	L			
Remove instream pumps and reduce use of near-channel wells	H				M	H			
Implement water conservation practices	M				L	L			
Improve community water system efficiency	M				L	M			
Color Key	Watershed-wide and/or seasonal impairment								
	Reach-specific or localized impairment								
	Suspected impairment								

The success of pollutant load reduction implementation will be tracked through the watershed monitoring program; see Chapter 9. The expanded monitoring program will also be used to refine the understanding of reach-specific impairments, as well as design and prioritize projects. The following table outlines the key indicators and criteria to be used in tracking pollutant load reduction and hydrologic condition success.

Table 7. Success criteria for pollutant load reductions and hydrologic condition improvements.

Criteria to track the success of pollutant load reduction projects		
Hydrologic Factors	**Dry-season flows**	Increasing trend in dry-season baseflow discharge and /or drought-period streamflow
	Infiltration/ Groundwater recharge	Increasing trend in dry-season water depths in upland wells
	Flood peaks/ Flashiness	Decreasing trend in streamflow flashiness
Pollutant Factors	**Turbidity**	Decreasing trend in winter baseflow and storm-event turbidity levels
	Temperature	Increasing trend in number of weeks with pool MWAT at or below 15°C during the dry season
	Dissolved oxygen	Increasing trend in number of weeks with average pool DO at or above 7 mg/L
	Nutrients	Maintain nitrate levels at or below 0.155 mg-N/L and orthophosphate (reported as total P) at or below 0.03 mg/L
	Pathogens	Fecal coliform: Maintain median 30-day levels at or below 50/100 ml with 10% of those samples not exceeding 400/100 ml
	Toxins/ Heavy metals	No criteria standards established

Color Key		
	Watershed-wide and/or seasonal impairment	
	Reach-specific or localized impairment	
	Suspected impairment	

Partnerships

The Salmon Creek Watershed is rich in partners. With no incorporated cities, a small population, and no municipal reservoirs, it has fostered an independent population of multi-generational ranch families, farmers, artists, and rural residents accustomed to taking care of themselves and their neighbors. Participation in watershed activities has been high with many people regularly attending public meetings, cooperating with Gold Ridge RCD on conservation projects, and expressing interest in the Save our Salmon (SOS) rainwater harvesting program. The SCWC and OAEC have been leaders with Gold Ridge RCD in creating a vision for a healthy watershed and bringing in funding for assessments, planning, and implementation. Salmon Creek School has just completed the first platinum LEED (Leadership in Energy and Environmental Design) certified building in Sonoma County; the school also includes a strong watershed-based environmental component in the curriculum. BLT, SLT, and SCAPOSD hold conservation easements in the watershed and promote good stewardship practices.

Bodega Water Company has been working with OAEC and Gold Ridge RCD to reduce its impact on summer flows. UCCE and NRCS have been stalwart partners in providing technical assistance to Gold Ridge RCD and landowners, as well as cost-share help through USDA programs. The NCRWQCB, CDFG, SCC, and NOAA Restoration Center have been major funders of watershed programs, and many other agencies have generously served as technical advisors.

Many of the actions in the Plan rely on partners to take the lead or provide support. Table 8 identifies the partners and their existing roles in the watershed. The following acronyms are used in the implementation summaries (Tables 9-13) that follow:

BAEDN	Bay Area Early Detection Network
BLT	Bodega Land Trust
CDFG	California Department of Fish & Game
CNGA	California Native Grass Association
MSWMA	Marin Sonoma Weed Management Area
NCRWQCB	North Coast Regional Water Quality Control Board
NOAA	National Oceanic and Atmospheric Agency's Restoration Center
NRCS	USDA Natural Resources Conservation Service
OAEC	Occidental Arts and Ecology Center
NCRWQCB	North Coast Regional Water Quality Control Board
SCC	State Coastal Conservancy
SCAPOSD	Sonoma County Agricultural Preservation and Open Space District
SCWC	Salmon Creek Watershed Council
SLT	Sonoma Land Trust
STRAW	Students and Teachers Restoring a Watershed
SWRCB	State Water Resources Control Board
TBD	To be determined
TU	Trout Unlimited
UCCE	University of California Cooperative Extension
$	$0 to $24,999
$$	$25,000 to $100,000
$$$	Over $100,000

Table 8. Existing programs and efforts in the Salmon Creek Watershed.

Watershed partners	Existing Program or Activity
Landowners	Ongoing stewardship activities including range and forest management, erosion control, invasive plant control, and riparian enhancement.
GRRCD	Outreach and education, water conservation and rainwater harvesting, instream habitat enhancement, streambank restoration, ranch planning, support of on-farm pollination programs, water quality monitoring, grassland monitoring, rural road improvements and assessments, manure management planning, watershed management planning, forest health, and grant writing
Salmon Creek Watershed Council	Outreach and education; community networking; watershed website; generator of and clearinghouse for ideas for grants and initiatives; support of GRRCD, OAEC, Salmon Creek School, and other's grant-funded watershed programs.
OAEC	Salmon Creek Water Conservation Program, outreach and education, estuary enhancement, forest health, landowner consulting, grassland monitoring, endangered species recovery efforts, including native beaver reintroduction, erosion control and stormwater management, grant writing and program development.
Bodega Water Company	Water conservation, rainwater harvesting
UCCE	Ranch water quality plans, assistance with water quality monitoring, and estuary research
Sonoma County Agricultural Preservation and Open Space District	Conservation easements, stewardship activities on District-owned properties
Bodega Land Trust	Conservation easements, outreach and education, stewardship activities on properties with easements
Salmon Creek School	Community education, green building and LID (low impact development) demonstrations, riparian and wetland enhancement
Bodega Volunteer Fire Dept	Rainwater harvesting, LID
California State Parks	Estuary protection and management
Ocean Song	Native grassland mapping and management, environmental education

Implementation summary

$ = $0 to $24,999 $$ = $25,000 to $100,000 $$$ = over $100,000

Table 9. Implementation of upland management recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
Uplands 1: Manage forests and woodlands to maintain diversity and ecosystem function.	1a. Provide education and technical support for landowners to manage healthy forests.	√ Conduct a watershed workshop or small-forest "fair." √ Provide information on websites. Distribute handouts at local events. √ Encourage landowners to work with NRCS to develop Forestry Conservation Action Plans (NRCS CAP). √ Promote management of existing redwood forest to encourage development of late seral stands. √ Coordinate with local conservation corps to provide low-cost work crews to assist landowners.	5 yrs	$ - $$	GRRCD or UCCE	Cal Fire Sonoma County Forest Conservation Working Group NRCS
	1b. Identify priority areas for forest and woodland conservation, including late-successional redwoods that provide habitat for special-status species.	√ Target high priority areas.	5 yrs	$$	SCAPOSD, SLT, BLT	Sonoma County Forest Conservation Working Group
	1c. Implement a fuel-load management program in cooperation with Cal Fire.	√ Target high priority areas. √ Organize neighborhood meetings with Cal Fire and local fire departments. √ Coordinate with local conservation corps to provide low-cost work crews to assist landowners. √ Assist neighborhoods in organizing and finding funding for chipping programs √ Assist landowners with NRCS EQIP practices	5 yrs	$-$$	FireSafe Sonoma	Landowners CalFire NRCS Sonoma County Forest Conservation Workgroup Local VFDs Neighborhood associations

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	1d. Determine the extent of Sudden Oak Death in the watershed and educate landowners about minimizing spread and managing infected forests.	√ Coordinate with UCCE to monitor extent of SOD. √ Create outreach materials to educate landowners about how to prevent SOD spread, treat diseased trees, and handle infected wood. Distribute at local events, other watershed workshops, and through websites. √ Develop, publish, and publicize BMP recommendations for private forest and woodland owners.	1-3 yrs	$-$$	UCCE	TBD
Uplands 2: Protect existing coastal prairie and other grasslands rich in native species and manage for healthy grasslands throughout the watershed.	2a. Support watershed ranchers in developing and implementing ranch plans that include sustainable grazing practices.	√ Coordinate with UCCE and NRCS to support ranchers in developing plans.	5 yrs	$$	MSWMA	Landowners UCCE NRCS GRRCD
	2b. Support local research and education efforts to identify and refine management strategies that promote native grassland species.	√ Establish and support demonstration sites for ongoing education. √ Provide a range of educational materials and tours for ranchers, small grassland owners, and the	1-3 yrs	$-$$	MSWMA	Sonoma Marin Coastal Grasslands Working Group GRRCD
	2c. Identify priority areas for native grassland conservation.	√	5 yrs	$$	Sonoma Marin Coastal Grasslands Working Group	SCAPOSD SCC Sonoma Coast State Park
	2d. Develop local seed sources for native grassland plants.	√ Develop database of locations where key grassland species for restoration occur, and where landowners are willing to allow seed collection. √ Offer workshops identifying key grassland species for restoration use, methods of seed collection, and options for seed increase.	5 yrs	$	MSWMA	Sonoma Marin Coastal Grasslands Working Group CNPS, Milo Baker Chapter

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
		√ Support development of a community seed bank.				CNGA
Uplands 3: Reduce impact of invasive species populations on habitat quality and function.	3a. Inform residents about invasive plant species, removal techniques and timing to avoid erosion and wildlife impacts, and native species suitable for residential or rangeland plantings.	√ Hold a weed-whacking workshop. √ Partner with local nurseries and distributors to provide free native plants, protectors, and other revegetation products to participants. √ Provide information on websites. Distribute handouts at local events.	5 yrs	$	MSWMA	Landowners SCWC
	3b. Promote removal of gorse, French broom, Scotch broom, and Himalaya blackberry infestations and replanting with appropriate native species.	√ Provide use of weed wrenches for a nominal fee. √ Organize neighborhood work parties. √ Provide free native plant(s) and disposal of invasive plant material.	5 yrs	$	MSWMA	Landowners SCWC
	3c. Monitor new occurrences of invasive species and contribute to regional weed management databases and efforts.	√	on-going	$	BAEDN	Landowners MSWMA
Uplands 4: Preserve undisturbed upland habitat and its connectivity.	4a. Identify and protect areas needed for wildlife corridors and critical habitat.	√	on-going	$$$	SCAPOSD	BLT SLT GRRCD
	4b. Encourage use of wildlife-friendly fencing	√ Develop informational materials to post on websites and distribute at workshops, local events, and landowner visits.	5 yrs	$	GRRCD	Landowners NRCS

Table 10. Implementation of instream and riparian enhancement recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
IR 1: Protect and increase existing riparian corridors.	1a. Increase and protect riparian corridor widths to improve function and habitat quality.	√ Educate landowners and residents about the benefits of riparian corridors and functional widths. √ Install riparian fencing along stream reaches accessed by livestock. √ Develop a program to assist rural residential landowners in managing their land for wider riparian corridors.	1- 3 yrs	$ - $$	GRRCD with assistance from NRCS	Landowners SCWC BLT SLT UCCE
	1b. Enhance riparian corridor structure complexity and species richness.	√ Educate landowners along riparian corridors on the components of a healthy riparian corridor. √ Install riparian fencing in reaches accessed by livestock. √ Plant riparian trees and herbaceous shrubs in riparian areas with insufficient density and complexity.	5 yrs	$ - $$	GRRCD with assistance from NRCS SCWC	Landowners BLT STRAW
IR 2: Increase instream channel complexity.	2a. Increase wood in stream channels.	√ Educate landowners and residents on the importance of large wood in stream channels, and the legal constraints on its unauthorized removal. √ Leave naturally downed large wood in channel, unless threatening infrastructure. √ Install large wood structures. √ See Recommendation 1 for actions to increase available wood and promote natural recruitment through riparian corridor enhancement.	5 yrs	$ - $$	GRRCD TU	Landowners BLT SCWC UCCE CDFG SWRCB SCC NOAA
	2b. Allow bank widening and inset flood bench development in reaches not constrained by buildings or infrastructure.	√ Use non-rock, biotechnical engineering practices to stabilize banks. √ Allow natural bank retreat and slumping.	5 yrs	$$	TBD	Landowners CDFG SWRCB SCC NOAA

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	2c. Promote tree establishment along the active channel and on stream banks for bank stabilization, live wood complexity, and undercut bank development.	√ Remove chronic disturbances, such as grazing (See Recommendation 1). √ Stabilize and slope eroding banks with bioengineering approaches and plant early successional riparian plants such as willow along with hardwood and conifer species. √ Leave or install large wood on active channel margins and banks to slow flood velocities, deposit fine sediment, and protect seedlings. √ Allow undercut banks to develop.	5 yrs	$$ - $$$	GRRCD	Landowners BLT STRAW TU SCWC NOAA UCCE CDFG SWRCB SCC
IR 3: Reduce fine sediment delivery and maintain gravel quality.	3a. Reduce fine sediment delivery from upland gully erosion, residential development, livestock operations, vineyards, and roads.	√ Educate landowners, construction operators, and public works departments on BMPs for reducing erosion and managing sediment delivery to streams. √ Improve grasslands and cross-fence pastures to reduce sheet and rill erosion on livestock ranches and dairy operations. √ Install riparian fencing to reduce streambank erosion. √ Decommission non- or under-used roads. √ Upgrade poorly designed roads. √ Document and repair upland gullies delivering sediment directly to the stream system.	Ongoing	$-$$$	GRRCD	Landowners SWRCB CDFG SCC NOAA
	3b. Improve in-channel complexity for the capture and sorting of suitable spawning gravels.	√ See Instream and Riparian Recommendation 2.	5 yrs	$$	GRRCD	Landowners SWRCB CDFG SCC NOAA

Table 11. Implementation of water quality enhancement recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
WQ 1: Minimize turbidity and the delivery of fine sediment from upland sources.	1a: Document and manage upland sediment sources.	√ Assess upland erosion sites for delivery of sediment to waterways. √ Maintain an on-going inventory of high-priority erosion control projects for use in funding and implementation decisions. √ Cooperate with landowners to implement identified high-priority erosion control projects.	Ongoing	$$-$$$	GRRCD	Landowners SCWC CDFG SCC NCRWQCB NRCS
	1b. Maintain, improve, or decommission rural roads.	√ Address sediment sources from road networks. Where possible, decommission roads that are no longer in use. √ For roads that are still in use, improve road design and maintenance practices to limit sediment production. √ Provide maintenance workshops and install demonstration projects as outreach to owners of dirt roads and driveways.	5 yrs	$-$$$	GRRCD	Landowners SCWC CDFG SCC NCRWQCB NRCS
	1c. Disconnect and filter sediment from waterways.	√ Increase the width, extent, and vegetative cover of riparian buffer throughout the watershed; see Instream Habitat Enhancement Action Plan in Chapter 5. √ Provide off-channel water sources for livestock by developing alternative water supply and providing pasture troughs. √ Construct sediment retention basins and infiltration swales along roadway drainage ditches to capture stormwater runoff and fine sediment. √ Install bioswales to slow stormwater runoff before it enters waterways √ Disconnect impervious surfaces	5 yrs	$$-$$$	GRRCD with assistance from NRCS OAEC	Landowners SoCo Dept. of Transport'n & Public Wks CDFG SCC NCRWQCB

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	1d. Promote soil retention.	√ Provide technical information and training on Best Management Practices for erosion control and farming practices to maintain topsoil.	1-3 yrs	$	GRRCD with assistance from NRCS	Landowners UCCE NCRWQCB
WQ 2: Maintain and improve summer water temperatures.	2a. Maintain and enhance dry-season flows.	√ See Chapter 7: Water Supply Sustainability Action Plan.			GRRCD	Landowners UCCE NCRWQCB CDFG NOAA
	2b. Maintain and Increase riparian canopy cover.	√ See Chapter 5: Instream Habitat Enhancement Action Plan.			GRRCD	Landowners UCCE NCRWQCB CDFG NOAA
	2c. Reduce and minimize turbidity.	√ See WQ Recommendation 1.			GRRCD	Landowners UCCE NCRWQCB CDFG NOAA
WQ 3: Increase summer DO levels in pools.	3a. Increase summer streamflows.	√ See Chapter 8: Water Supply Sustainability Action Plan.				
	3b. Reduce summer water temperature.	√ See WQ Recommendation 2.				
	3c. Reduce nutrient loads.	√ See WQ Recommendation 4.				
WQ 4: Minimize nutrient and pathogen delivery.	4a. Restrict direct livestock access to	√ Provide technical information to horse owners and other rural residents with small numbers of	1-3 yrs	$	GRRCD with assistance from NRCS and	Landowners NCRWQCB

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	streams and riparian areas.	confined animals. √ Support use of riparian fencing, pasture management, water development, and other strategies to protect waterways.			UCCE	CDFG NOAA Sonoma County Farm Bureau
	4b. Upgrade inadequate septic systems adjacent to waterways.	√ Provide information to landowners on the importance of maintaining a well-functioning septic system to a healthy stream. √ Coordinate with Sonoma County PRMD to streamline permitting to upgrade or replace inadequate systems. √ Seek funding to assist landowners with onsite wastewater treatment systems.	5 yrs	$$	TBD	Landowners SoCo PRMD NCRWQCB
	4c. Reduce use of nitrate- and phosphate-rich products.	√ Develop and distribute a comprehensive list of effective alternatives and methods for reducing quantity of use. √ Develop demonstration sites for reduced fertilizer and pesticide gardening and farming. √ Educate landowners about reducing the use of phosphate soaps to lessen associated phosphate pollution through insufficient filtration by onsite wastewater treatment systems.	1 -3 yrs	$	TBD	Landowners MSWMA BAEDN UCCE SoCo Agric. Commissioner's
WQ 5: Promote minimal use and proper disposal of toxic compounds.	5a. Keep stormwater on site.	√ Use educational materials, workshops, and demonstration sites to encourage the use of measures such as rainwater catchment, low-impact design, swales, and infiltration ponds to retain stormwater.	1- 3 yrs	$	TBD	OAEC UCCE NCRWQCB County of Sonoma

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	5b. Educate community on pollutants of concern and how to reduce water contamination.	√ Develop and distribute educational materials on websites, at workshops and community events, and on toxic round-up days (see Action 5c). √ Include information on proper use and disposal of household toxics, and safe alternatives. √ Include guidelines for proper drainage of swimming pools and spas.	1 – 3 yrs	$	TBD	SoCo Envt'l Health SCWC
	5c. Promote proper disposal of toxic products.	√ Hold well-publicized toxics round-up days quarterly to assist landowners with safe disposal of unwanted compounds.	1 – 3 yrs	$	TBD	

Table 12. Implementation of water supply sustainability recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
WS 1: Develop storage-based water supplies to reduce reliance on, and utilization of, extractive sources.	1a. Develop off-channel ponds and distribution systems.	√ Evaluate agricultural producer's water supply sources to target those using instream or riparian sources.	1 – 3 yrs	$$$	GRRCD	Landowners NRCS CDFG SWRCB NOAA
	1b. Install roofwater harvesting systems.	√ Design and install roofwater catchment systems to replace non-potable water uses from extractive sources and increase water supply security. √ Consider installing roofwater catchment systems where potable supplies are unreliable, water quality is poor, or water source is a stream diversion.	1 – 3 yrs	$$ - $$$	GRRCD BWC OAEC	Landowners NRCS CDFG SWRCB NOAA
	1c. Support landowners in reducing or eliminating dry-season use of instream pumps and near-channel wells.	√ Conduct an education and outreach program to inform residents of the ecological impacts of using their riparian water rights. √ Develop off-channel storage and roofwater harvesting systems to replace riparian water sources – see Water Supply Actions 1a and 1b above. √ Develop program to enroll landowners in abstaining from using their riparian rights for the purpose of salmonid habitat improvements.	1 – 3	$ - $$$	GRRCD OAEC BWC	Landowners NRCS TU SWRCB NOAA
WS 2: Reduce water demands.	2a. Implement water conservation program to minimize consumption	√ Conduct watershed-wide workshops to educate residents and encourage water conservation practices, such as: √ Work with County to develop and distribute information on programs that assist landowners in implementing water conservation projects, such as water use audits and SCEIP. √ Research and develop programs that	1 – 3 yrs	$	OAEC	GRRCD PRMD County of Sonoma TU SCWA

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
		assist landowners with financial hardships to replace old faucets and appliances with high efficiency devices.				
	2b. Structure water rates to support water conservation and reduce dependence on water supply from sources critical for aquatic habitat.	√ Address high unaccounted-for water losses in community systems √ Implement conservation rate structure				
WS 3: Recharge springs and groundwater.	3a. Increase infiltration in upland recharge areas and up-gradient from springs.	√ Install rain gardens to capture excess runoff. √ Install contour infiltration trenches and infiltration swales to temporarily hold and infiltrate runoff. √ Direct excess runoff into catchment basins that store and allow slow infiltration. √ Replace impervious surfaces such as parking areas and patios with pervious materials (grass pavers, porous concrete, and other pervious pavers). √ Effectively manage grasslands and forests; see Chapter 4 Uplands Action Plan.	5 yrs +	$$$	TBD	
	3b. Reduce stormwater runoff in uplands.	√ See Chapters 4: Uplands Action Plan and 6: Water Quality Action Plan.	5 yrs +	$ - $$	TBD	

Table 13. Implementation of agricultural sustainability recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
Ag 1: Facilitate opportunities for producers to locally process and market agricultural products.	1a. Promote and sustain agriculture-related industries in or near the watershed and develop forums for linking them with producers.	√ Seek funding to support establishment of businesses that provide services, such as processing, storage, bottling, canning, and packaging. √ Address regulatory hurdles to on-farm livestock processing or "mobile slaughterhouses."	5 yrs+	$ - $$	GRRCD	Producers Community Alliance with Family Farmers UCCE Sonoma County Farm Bureau Local distributors
	1b. Develop a watershed "brand" synonymous with locally produced, sustainable, high-quality farm products.	√ Work with public outreach organizations to promote public appreciation for local agriculture. √ Develop educational opportunities to teach producers about marketing strategies and business management. √ Assist in the development of effective distribution channels for locally produced goods. √ Assist farmers in developing value-added marketing plans for their products while establishing an overall market presence for the watershed as its own appellation.	5 yrs	$	GRRCD	Producers Community Alliance with Family Farmers UCCE Local distributors Farm Trails LandPaths Local farmers' market organizers Farmers/ranchers in the watershed Sonoma County Farm Bureau
Ag. 2: Preserve open space and rural landscapes by keeping large agricultural parcels intact and their operations viable.	2a. Support producers in diversifying income and seeking financial assistance.	√ Assist producers to participate in programs that provide additional capital to support agricultural land values, such as conservation easements through the Williamson Act. √ Coordinate with NRCS staff to assist producers in developing Farm Bill program contracts. √ Work with agricultural landowners to explore other farm-related income options, such as farm tours.	Ongoing	$$$	SCAPOSD	Producers SLT BLT GRRCD NRCS Farm Trails LandPaths Sonoma County Farm Bureau

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
Ag 3: Ensure sustainable resource use in agricultural production.	3a. Work with vineyard operators to reduce water use.	√ Provide workshops and technical support for vineyard dry-farming. √ Assist vineyard operators in acquiring support through NRCS and RCD programs to develop water conservation measures. √ Work with vineyard operators to understand and remain a step ahead of groundwater regulation measures as they develop. √ Educate the local community on vineyard practices.	5 yrs	$	GRRCD with assistance from NRCS	Vineyard Operators and Landowners Sonoma County Grape Growers Association Sonoma County Farm Bureau Community Alliance with Family Farmers Local vineyard operators
	3b. Assist rangeland and dairy operators in implementing water quality protection measures.	√ Provide workshops and technical support for dairy and rangeland operators to assist in compliance with water-quality regulations. √ Assist rangeland and dairy operators in acquiring assistance through NRCS and RCD programs to protect riparian areas.	5 yrs	$	GRRCD with assistance from NRCS	Straus Family Creamery Clover-Stornetta Farms NCRWQCB UCCE
	3c. Assist livestock operators to develop and implement nutrient management plans.	√ Implement a proactive, on-farm nutrient management program that will include a "user-friendly" nutrient budgeting model, soil, vegetation, and manure sampling protocols, and a land application tracking system. The program will assist watershed dairy and livestock operators with the ability to write nutrient management plans based on facility inventories and nutrient budgeting information. √ Secure funding to effectively develop nutrient management or conservation plans for all livestock operators. √ Provide technical assistance to dairy and livestock operators to conduct on-farm facilities inventories and	5 yrs	$	GRRCD, with assistance from NRCS and UCCE	Landowners Western United Dairymen Sonoma County Farm Bureau

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
		nutrient budgeting. √ Conduct, soil, vegetation, and manure sampling to identify the proper organic fertilizer application rates for farm fields. √ Complete nutrient management plans and land application tracking systems. √ Use buffer strips to trap sediment from confined animal and other high-use areas. √ Work with interested landowners to develop waste-to-profit systems, suchc as methane digesters and on-site fertigation equipment.				

Project selection criteria and process

Gold Ridge RCD is taking the lead for implementing many of the Plan actions. The RCD has been working for nearly 70 years to help coordinate funding resources with landowner needs and will use the Plan to solicit and distribute additional funding for the Salmon Creek Watershed. The following process describes how the RCD will assess and select projects. It recognizes that different funding sources have varying requirements and that additional selection criteria may be needed to fit specific funding programs as well as fulfill resource protection and enhancement goals.

Proposed project selection criteria include:

1. Improvement of water quality,
2. Enhancement of summer streamflow,
3. Protection, restoration, or enhancement of one or more natural processes [e.g., restoration of riparian vegetation that will provide shade, LWD, and bank stability over many years; modification of stream crossings to allow sediment transport and movement of aquatic species; and removal of nonnative invasive plants),
4. Improvement of habitat connectivity,
5. Support of habitat for a diversity of plant/animal species or protection of vital habitat features for special status watershed wildlife species,
6. Addressing causes as well as or instead of symptoms,
7. Strong landowner commitment,
8. Pilot project that will promote additional projects,
9. Support for sustainable agriculture,
10. Technically sound and effective design solution is feasible, and
11. Cost is reasonable for benefits.

Projects would not necessarily need to meet all criteria to be selected. For example, improving drainage on an unsurfaced road may score high in a program to reduce turbidity even though it would not increase summer streamflows or improve connectivity.

Table 14. Gold Ridge RCD project selection process.

	Step	Who	Estimated Day of Completion (from start)	Outcome
1	Adapt overall criteria as needed to fit specific funding source.	GRRCD with funder	14	Criteria meet funding requirements as well as overall watershed goals.
2	Assemble project selection advisory committee (SAC).	GRRCD	30	Advisory team is in place, if needed, and will make recommendations to GRRCD Board.
3	Inform watershed landowners through website, newsletters, and mailings.	GRRCD	60	Watershed landowners are informed of funding opportunities and the selection process.
4	Select project review team.	GRRCD with input from SAC	45	Field team is in place to visit each site and score it according to criteria.
5	Conduct site visits, score projects, and present findings to SAC.	Review team w/ GRRCD staff support	120	SAC and GRRCD staff have an objective evaluation of potential projects.
6	SAC makes project recommendations to GRRCD Board.	SAC	150	GRRCD staff will present recommendations to the GRRCD Board of Directors. The Board will have a thoroughly considered set of projects to approve.
7	GRRCD Board makes final selection and directs staff to proceed.	GRRCD Board	180	Selection completed.

Outreach and education

Outreach and education are fundamental to the success of the Plan. They maintain the visibility and urgency of the need to care for the Salmon Creek Watershed. They provide an avenue for Gold Ridge RCD and program partners to get feedback from watershed residents on how Plan actions are working and to share ideas on how to improve them. For those recommended actions, that rely on voluntary activities by watershed residents, such as control of invasive plant species or water conservation measures, education is the primary access project partners have for implementation.

Outreach and education activities also offer a vital role for organizations that may not be able or willing to manage construction contracts or negotiate landowner agreements, but may have the time, neighborhood connections, and/or long-term funding support necessary for effective outreach. Salmon Creek Watershed Council, local schools and neighborhood organizations, and some County agencies are key partners for outreach and education.

In addition to specific actions in Chapters 3-7, overall strategies for soliciting and distributing information include:

- Gold Ridge RCD and watershed partner newsletters and websites. Excellent resource for announcements of new funding for landowners, tours, and workshops; background information on the watershed; and downloadable reports and brochures.
- Shared electronic calendar. Used by watershed partners to coordinate activites. Accessible as read-only by residents.
- Tours and public meetings. Specific subjects are addressed in the action chapters. Neighborhood-scale meetings and tours may be especially effective for some topics such as small forest management where collective projects between neighboring landowners are optimal.
- Regular watershed summit. A festive annual or biennial event to bring together scientists, residents, and watershed partners for reports and discussion on the state of the watershed. Should include food and art produced in the watershed.
- Presentations and information booths at community events. Enroll the organizers into choosing the watershed as a theme for an upcoming annual Bodega Fire Department community quilt project.
- Presentations at trade associations such as Farm Bureau, Woolgrowers, Cattlemen's, and others.
- Presentations and participation at conferences to share Salmon Creek progress and to bring new information back to the watershed.
- Collaboration with Harmony Union School District on watershed events and projects.

Funding

Although many projects are already underway in the Salmon Creek Watershed as described above, additional funding is needed to fully implement the Plan. Gold Ridge RCD has already been awarded funding for implementation through the Integrated Regional Water Management Program (IRWMP) and the American Recovery and Reinvestment Act (ARRA) from NOAA, and is actively seeking additional funding. Non-profit project partners are also eligible to receive funding from many state and federal agencies, as well as from foundations. In addition to help from Gold Ridge RCD and other project partners, eligible private landowners have direct access to federal cost

share programs through NRCS and USFWS, state cost-share assistance from CalFire, and low-interest loans through the Sonoma County Energy Independence Program. Table 15 identifies funding sources for Plan implementation.

Table 15. Local, state, federal, and foundation funding sources.

Funding Entity	Program
Local Sources	
Sonoma County	Energy Independence Program. Provides low-interest loans to private and commercial property owners for water and energy conservation measures. Loans are repaid through voluntary property tax assessments.
Sonoma County Agricultural Preservation and Open Space District	Protects land through purchasing development rights and acquiring easements. Project selection is based on consistency with the current Acquisition Plan and available funding.
State Agencies	
State and Regional Water Boards	319(h) Nonpoint Source. Funding is through the USEPA and is intended to result in improved water quality through projects that address TMDL implementation or problems in streams, bays, rivers, and lakes that have been listed as impaired. Small Community Wastewater Grant Program. The program provides assistance for planning, design, and construction of publicly owned wastewater treatment and collection systems. Clean Water Revolving Loan Fund. Provides low-interest loans for stormwater and wastewater treatment, and implementation of projects to reduce nonpoint source pollution. Integrated Regional Water Management Grant Program. The intention is to integrate sustainable and reliable water supply, better water quality, stormwater management, environmental stewardship, and a strong economy.
CDFG	Fisheries Restoration Grant Program. This is a long-standing competitive grant program funded by both state and federal sources. Funding can be used for planning, barrier removal, habitat restoration, monitoring, public involvement, maintenance, and education for projects consistent with current CDFG priorities.
State Coastal Conservancy	Funding is primarily through voter-approved bond funds. Provides funding for projects to purchase, protect, restore, and enhance coastal resources.
Department of Water Resources (DWR)	Groundwater program. Includes a range of grants for groundwater monitoring and management. Integrated Regional Water Management Grant Program. DWR administers IRWM grants through Proposition 84. DWR also manages many other grant and loan programs.

	Fire Prevention Program. Fire-safe landscaping for homeowners and communities.
Cal Fire	California Forest Improvement Program (CFIP). Provides cost-share assistance to private landowners, RCDs, and non-profit groups for planning, planting, fish and wildlife habitat improvement, and land conservation practices.
California Department of Public Health	Safe Drinking Water State Revolving Fund. Provides funding to correct public water system deficiencies. Selection is based upon a prioritized funding approach that addresses public health risks, compliance with requirements of the Safe Drinking Water Act, and need on a per household affordability basis.
Federal Agencies	
USEPA	The USEPA website features an extensive catalog, sorted by keyword (e.g., invasive species, monitoring, land acquisition, watershed management), of federal funding sources for watershed protection (http://cfpub.epa.gov/fedfund/keyword_list.cfm).
U.S. Fish and Wildlife Service	Cooperative Conservation Initiative. Provides cost-share assistance to private landowners to restore natural resources and establish or expand wildlife habitat.
NOAA Fisheries	Open Rivers Initiative provides funding and technical expertise for community-driven, small dam and river barrier removals. NOAA Restoration Center Regional Partnerships provide funding for multi-year regional habitat restoration partnerships including watershed-scale projects that yield significant ecological and socioeconomic benefits. National Association of Counties and NOAA are partners in the Coanties Restoration Initiative (CCRI). CCRI encourages innovative, county led or supported projects that restore important marine and coastal habitats and National Association of Counties and NOAA are partners in the Coastal Counties Restoration Initiative (CCRI). CCRI encourages innovative, county-led or supported projects that restore important marine and coastal habitats and living resources. These projects also develop the capacity of county governments, citizens groups and other organizations to conduct community-based restoration that will enhance local watershed-based resource management and promote stewardship.
Natural Resources Conservation Service (NRCS)	NRCS manages a suite of programs to provide technical and cost-share assistance to implement conservation practices, primarily for owners of land in agricultural production. http://www.ca.nrcs.usda.gov/programs/ The Environmental Quality Incentives Program (EQIP) was established in the 1996 Farm Bill to provide a single, voluntary conservation program for farmers and ranchers to address significant natural resource concerns. Nationally, it provides technical and financial assistance to address natural resource concerns. Administered by the Natural Resources Conservation Service (NRCS), EQIP was reauthorized in the 2008 Farm Bill and awards cost share assistance to projects which provide significant

	The Environmental Quality Incentives Program (EQIP) was established in the 1996 Farm Bill to provide a single, voluntary conservation program for farmers and ranchers to address significant natural resource concerns. Nationally, it provides technical and financial assistance to address natural resource concerns. Administered by the Natural Resources Conservation Service (NRCS), EQIP was reauthorized in the 2008 Farm Bill and awards cost share assistance to projects which provide significant environmental benefit. Eligible farmers and ranchers may apply for EQIP program benefits at any time. The Healthy Forest Reserve Program is a voluntary program established for the purpose of restoring and enhancing forest ecosystems. It can provide cost-share for conservation practices, a conservation easement in exchange for market value, and Safe Harbor from future regulatory restrictions under the Endangered Species Act. The Agricultural Water Enhancement Program (AWEP) is a voluntary conservation initiative that provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural land for the purposes of conserving surface and ground water and improving water quality. As part of the Environmental Quality Incentives Program (EQIP), AWEP operates through program contracts with producers to plan and implement conservation practices in project areas established through partnership agreements. The Conservation Stewardship Program encourages land stewards to improve their conservation performance by installing and adopting additional activities, and improving, maintaining, and managing existing activities on agricultural land and nonindustrial private forest land. Through the Conservation Stewardship Program, NRCS will provide financial and technical assistance to eligible producers to conserve and enhance soil, water, air, and related natural resources on their land. Eligible lands include cropland, grassland, prairie land, improved pastureland, rangeland, nonindustrial private forest lands, agricultural land under the jurisdiction of an Indian tribe, and other private agricultural land (including cropped woodland, marshes, and agricultural land used for the production of livestock) on which resource concerns related to agricultural production could be addressed.
Other Sources:	
National Fish and Wildlife Foundation (NFWF)	NFWF has a number of programs that could apply including: Native Plant Conservation Initiative supports projects that protect, enhance, and/or restore native plant communities.

Permits

Many of the actions recommended in the Plan will require permits from local, state, and federal agencies. For example, work in a stream requires permits from the U.S. Army Corps of Engineers, RWQCB, CDFG, and, under certain circumstances, Sonoma County; if listed species are potentially present, a permit is needed from USFWS or NOAA Fisheries; and if the project is in the Coastal Zone, a Coastal Development Permit is needed. Acquiring permits can be a lengthy process. Involving regulators in the initial stages can help to address concerns early in the project design process and reduce delays after the application is submitted. Grouping similar projects, such as multiple large woody debris structures in one tributary, can also save time and cost.

CHAPTER 9: TRACKING WATERSHED MANAGEMENT PLAN OBJECTIVES

The assessment and monitoring programs presented in this chapter were selected to address existing data gaps, assist landowners and natural resource managers in their efforts to protect and enhance the natural resource base of the watershed, and provide guidance in the implementation of this watershed management plan. The recommended assessment and monitoring programs are designed to answer two questions:

- Are Salmon Creek and its tributaries currently achieving the water quality objectives established by the North Coast Regional Water Quality Control Board?
- Are the beneficial uses of Salmon Creek being maintained and protected, and, if not, what are the limiting factors?

Monitoring is a technical term that denotes collecting a series of observations over time in order to detect changes or trends. Monitoring programs can be very expensive and labor intensive. The repetition of measurements over time for the purposes of detecting change distinguishes monitoring from inventory and assessment. Although inventories and assessments can be based on a single measurement or observation, they can also incorporate a series of observations to either gauge conditions before and after some management action or change or to gain a more accurate estimate of a specific parameter. Often, an assessment or inventory will serve as a first step towards developing a longer term monitoring program. Assessments and inventories can provide important information on baseline or current conditions if conducted properly.

Recommended Monitoring and Assessment Programs:

1. Surface Water Ambient Monitoring Plan
2. Bioassessment Monitoring
3. Geomorphic Monitoring
4. Fisheries Monitoring
5. Streamflow Monitoring
6. Riparian Assessment
7. Residual Dry Matter (RDM) Assessment
8. Manure Land Application Tracking and Assessment

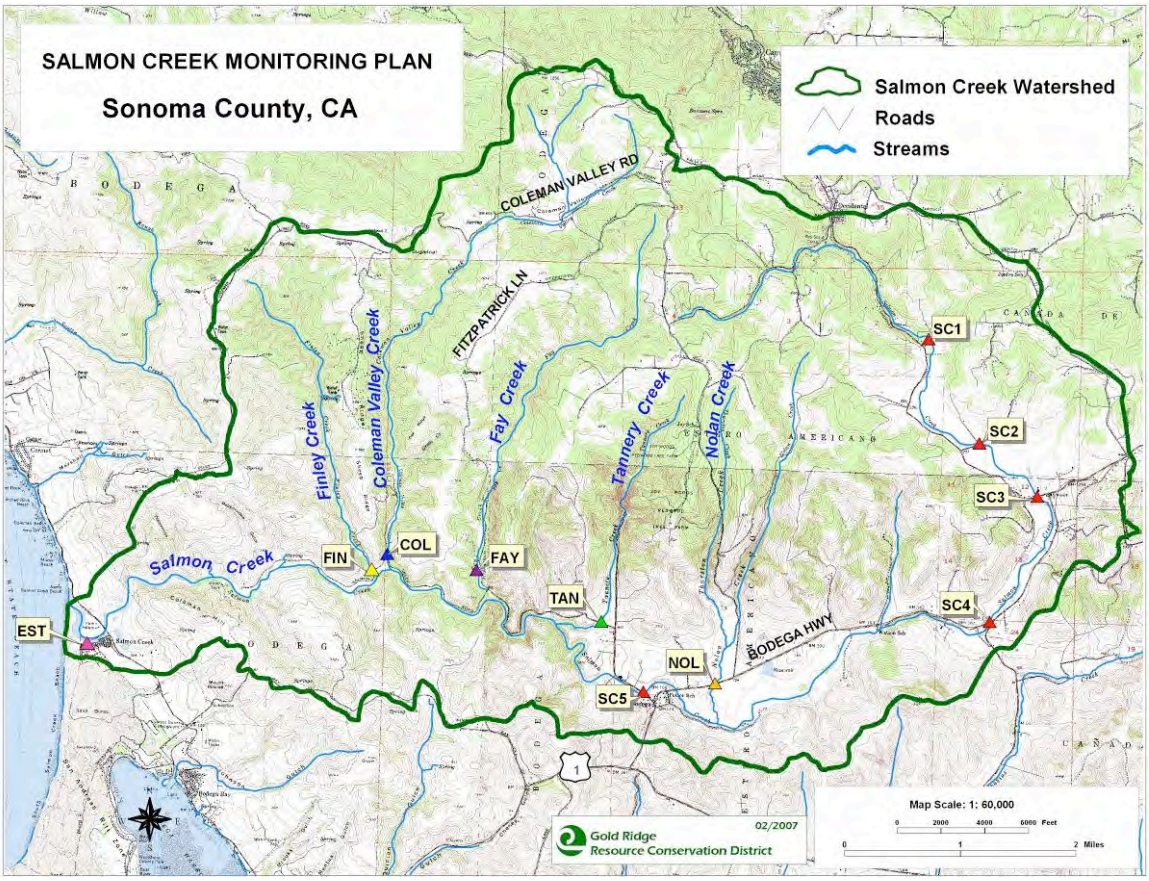
1. Surface Water Ambient Monitoring Plan (MP)

Gold Ridge RCD prepared a water quality monitoring and assessment program plan as a component of the development of the SCICWMP. The purposes of the MP were to assess the overall health of the Salmon Creek Watershed and to establish current baseline conditions. (Refer to Chapter 5 for an analysis of water quality and the associated goals, recommendations, and actions.)

The objectives of monitoring selected locations in the Salmon Creek Watershed were to:

- Document baseline conditions to allow for comparison with future and as yet unplanned monitoring. This comparison will provide for assessment of management measure effectiveness and serve as a guide for the systematic development of restoration projects;
- Assess the efficacy and necessity of future water quality improvement projects; and
- Use the water quality monitoring data as a benchmark for developing watershed-wide BMPs.

Figure 12. Water quality monitoring sites map.



How the Monitoring Data Was Used

Because the SCICWMP is a planning document rather than an implementation project, the overall plan sought to characterize existing conditions in the watershed at a planning level, enabling the development of site-specific restoration or remediation projects. The data gathered provided the information necessary to make implementation decisions necessary at the reach scale.

Pre-project Conditions and Water Quality

Standardized water quality monitoring data were not available for the Salmon Creek Watershed at the onset of this project. Available stream ambient water quality data had been collected by SCWC through a volunteer monitoring program funded by CDFG (2003-2006). A summary of this information is included in Chapter 5, and the full report is found in Appendix B.

Additional Monitoring Objectives

The current Gold Ridge RCD monitoring program should continue in order to document long-term trends and watershed-scale responses to the implementation of recommended BMPs.

Monitoring Activities

Sampling and analysis will include field-measured parameters and laboratory analysis for selected parameters that are key indicators of water quality. Field-measured parameters will include stream discharge, temperature, DO, conductivity and pH.

With the exception of temperature and DO, water quality sampling will be done monthly and in response to the storm events. Grab samples will be taken for turbidity and TSS analyses. These samples will be taken from the established monitoring and other suitable locations where access is granted by landowners. Additional monitoring that is outside of Gold Ridge RCD's SWRCB-approved monitoring plan and quality assurance project plan are noted as recommendations below.

WQ Monitoring Recommendation 1: Conduct and implement a continuous temperature monitoring program throughout the Salmon Creek Watershed during low-flow conditions.

Scientific Reasoning

Watersheds and their associated biological communities are complex. A wide range of watershed conditions and human activities can affect water quality in ways that aren't always obviously related. Temperature, for example, affects both water chemistry and the biological functions of aquatic organisms. Water temperature influences the amount of oxygen that can be dissolved in water, the rate of photosynthesis by algae and other aquatic plants, the metabolic rates of aquatic organisms, the sensitivity of organisms to toxic wastes, parasites and diseases, and timing of reproduction and migration.

The impacts on water quality from watershed conditions and human activities depend on the type of activity and its timing, location, duration, and intensity. Many land uses affect the watershed function and contribute pollutants to the stream system. The mobilization, movement, and concentration of pollutants vary by season, by day, and sometimes from hour to hour. This can make it difficult to accurately measure representative water quality conditions. It is critical to build a data record over time to assess how different conditions affect water quality throughout a watershed.

Instream water temperatures vary both spatially and temporally (diurnally and seasonally) throughout a watershed. High stream temperatures are of most concern during the lower flow, higher air temperature conditions of summer and fall. See Water Quality Recommendation 2 in Chapter 5 for an overview of the importance of and potential impacts on water temperature.

Most water quality monitoring is conducted via grab samples and subsequent chemical analysis. Grab sampling takes a snapshot of the water quality conditions occurring at that particular spot at that particular time. However, water quality sampling can be designed to take a number of instantaneous samples over time to examine trends in water quality (e.g., decline or improvement) and to potentially catch a pollution event or critical threshold condition when it occurs. This sampling method has been occurring on a monthly basis through the volunteer and professional monitoring efforts, but a finer scale, more frequent monitoring design can greatly assist with the use of water quality data to assess the quality of aquatic habitat.

Implementation Measures

- Calibrate and deploy continuous temperature data loggers throughout the Salmon Creek Watershed in order to spatially represent stream temperature

conditions, particularly to evaluate the effects of thermal inputs from significant tributaries.
- Collect continuous temperature data throughout the watershed at 30-minute intervals from May through October.
- Depending on the sampling design, either deploy data loggers in the areas with highest quality aquatic habitat values to evaluate the thermal refugia available to aquatic organisms or, conversely, deploy loggers in areas where stream temperatures are thought to be a limiting factor to the survival and persistence of sensitive aquatic organisms.
- Coordinate with other associated monitoring efforts, such as UCCE coho broodstock monitoring program, to maximize monitoring data and funding resources, and make data applicable to as many assessment and restoration efforts as possible.

WQ Monitoring Recommendation 2: Conduct and implement a continuous DO monitoring program throughout the Salmon Creek Watershed during low-flow conditions.

Scientific Reasoning

DO concentrations vary diurnally and seasonally based on stream temperature, biological and chemical oxygen demands, and aquatic organism respiration. See Water Quality Recommendation 3 in Chapter 5 for more information about how DO levels influence the growth, reproduction, and survival of aquatic organisms.

Salmon Creek volunteer water quality monitoring.

Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, algae, leaves, grass clippings, manure, or sewage is present in a stream, particularly under low-flow conditions, bacteria will begin the process of breaking down the waste. When this happens, DO is consumed by aerobic bacteria, decreasing the DO concentration and lessening the amount available to other aquatic organisms.

Additionally, the presence of aquatic plants such as algae can cause diurnal fluctuations in DO concentrations. Photosynthetic processes under daylight conditions can artificially increase the DO content, creating super-saturated (>100% saturation) DO conditions, while oxygen levels drop at night due to consumption during the respiration of aquatic plants and animals. Most monitoring is conducted during the daytime, which biases measurements towards the higher DO concentration conditions while missing the critical low DO conditions, which are lowest just before dawn.

As stated in Water Quality Recommendation 3, DO concentrations can "vary rapidly, but even short episodes of very low oxygen can cause critical impairment and mortality to aquatic organisms." To measure these seasonal and diurnal variations in DO concentration, continuous DO meters should be deployed under low-flow conditions in

reaches where DO concentration is thought to be a limiting factor for sensitive aquatic organisms.

Implementation Measures

- Calibrate and deploy continuous DO data loggers throughout the Salmon Creek Watershed in order to spatially represent DO concentration conditions, particularly in areas where DO levels are thought to be a limiting factor.
- Collect continuous DO concentration data in as many locations as possible at 30-minute intervals from May through October. However, deployable DO meters are expensive, and it will likely only be feasible in a couple of locations.
- Depending on the sampling design, either deploy loggers in the areas with highest quality aquatic habitat value to evaluate the refugia available to aquatic organisms or, conversely, deploy loggers in areas where DO levels are thought to be a limiting factor to the survival and persistence of sensitive aquatic organisms.
- Coordinate with other monitoring efforts, such as NCRWQCB SWAMP monitoring program, to maximize monitoring data and funding resources, and make data applicable to as many assessment and restoration efforts as possible.

2. Bioassessment Monitoring

Another monitoring strategy is bioassessment—employing stream biota to assess the water quality conditions and overall stream health. By looking at and analyzing the type, number, distribution, age, and size of aquatic macroinvertebrates, algae, fish, etc., one can infer a wide range of information about the quality of water and habitat over time. The mere presence or absence of certain common sensitive species can provide information about both the quality of the water and the ability of that stream to support other sensitive species.

Bio Monitoring Recommendation 1: Conduct and implement a bioassessment monitoring program, including benthic macroinvertebrate (BMI) and algae community sampling, to evaluate aquatic conditions and suitability for sensitive aquatic organisms.

Scientific Reasoning

The use of multiple bioindicators, such as adding algae to BMI sampling, will facilitate the "weight-of-evidence" approach to interpretation of biomonitoring results, which can be used to corroborate assumptions about stressors and limiting factors for stream biota. As primary producers, algae are the most directly responsive of the common bioindicators to nutrients and can be very valuable for assessing nutrient impairment (Fetscher & McLaughlin 2009).

Implementation Measures

- Conduct monitoring using SWAMP bioassessment protocols and producing data that is SWAMP-compatible.
- Depending on the sampling design, either sample BMIs in the areas with highest quality aquatic habitat value during spring to characterize the refugia available to aquatic organisms or, conversely, sample BMIs in the fall in areas where stream conditions are thought to be a limiting factor to the survival and persistence of sensitive aquatic organisms.

- Conduct algae community monitoring in conjunction with BMI monitoring.
- Coordinate with other monitoring efforts, such as NCRWQCB SWAMP and/or UCCE coho broodstock monitoring program, to maximize monitoring data and funding resources, and make data applicable to as many assessment and restoration efforts as possible.

3. Geomorphic Monitoring

Improving instream habitat for salmonids and other aquatic organisms is a stated goal of this Plan, and many of the implementation recommendations were developed to meet this goal. Five geomorphic reference reaches were established in 2006 to quantify channel morphology and sediment-related habitat conditions; see Appendix A. The reference reaches were monumented for repeat measurements and long-term monitoring. In addition to the detailed reference reaches, sections of Salmon Creek Watershed were assessed for LWD frequency, pool characteristics, streambank erosion, and channel type. In 2001 and 2002, CDFG performed habitat assessments along mainstem Salmon Creek and all the major tributaries. Evaluating the ecological effectiveness of many of the proposed implementation projects in this Plan requires long-term, repeated monitoring of the stream's geomorphic conditions.

Geomorphic Monitoring Recommendation 1: Implement a long-term monitoring program in Salmon Creek to track instream physical habitat conditions and document Plan effectiveness.

Scientific Reasoning

Agencies tasked with recovering salmonid populations and protecting beneficial uses of the northern California waterways have been developing standards to measure instream habitat quality (CDFG 2004; RWQCB 2006a and 2006b; NMFS 2010). National Marine Fisheries Service (2010) has compiled many of the habitat condition indicators and set rankings and targets for the indicators; see Table 16 below for geomorphic-related indicators. To improve the viability of streams for salmonid population recovery, it is necessary for existing habitat conditions to be ranked as GOOD, or for conditions to be trending towards GOOD over time.

Table 16. Related coho salmon habitat-quality indicators and their target values.
Compiled and developed by NMFS Southwest Region (NMFS 2010)

Habitat Attribute	Indicator	Ranking		
		Poor	Fair	Good
Pool Habitat and Velocity Refuge	Frequency of Primary Pools	<30% pools by length	30-40%	40-50%
	LWD Frequency	<4 key pcs/100m	4-6/100m	6-11/100m
	Shelter Rating	Score of <60 per km	60-80	80-100
Riparian Vegetation	Canopy Cover	<75% avg. over km	75-85%	85-95%
	Species Composition	<25% of historic diversity	25-50%	>50%

Implementation Measures

- Resurvey and sample geomorphic reference reaches every 5 to 10 years (depending upon upstream projects and hydrologic conditions) to track changes in channel features related to instream habitat conditions. Parameters to be monitored include:
  - Channel longitudinal profile and cross sections (pool depths, riffle/pool spacing, bankfull dimensions, floodplain development).
  - Bed sediment size distribution (riffles).
  - V* or pool fine sediment volume.
  - Canopy cover and riparian buffer width/complexity; see RA Monitoring Recommendation #1.
  - Instream shelter rating.
- Locate, monument, and survey other geomorphic reference reaches as needed.
- Survey LWD and pool frequency throughout salmonid bearing sections of watershed every 10 years to track habitat conditions, as well as effectiveness of implementation and outreach projects. Compare data to baseline conditions in 2006 and salmonid habitat metrics.

4. Fisheries Monitoring

In response to the precipitous decline of coho salmon populations throughout northern and central coastal California, landowners and agencies have engaged in conservation and restoration of critical habitat. These efforts in Salmon Creek Watershed have opened the door for the next step in coho salmon recovery efforts, the reintroduction of the endangered species through release of adult fish into the watershed.

Fisheries Monitoring Recommendation 1: Monitor fish populations to assess success of reintroduction of coho salmon into the Salmon Creek Watershed.

Scientific Reasoning

In an effort to reestablish coho salmon populations in the Salmon Creek Watershed, CDFG released adult fish from the Russian River Coho Broodstock Program into the mainstem of Salmon Creek in December 2008 and 2009. No follow-up monitoring has been conducted by the program, although CDFG supported Gold Ridge RCD in conducting spawning surveys in 2009.

The most efficient way to measure the success of coho salmon reintroduction and recovery efforts is to directly monitor the presence, abundance, and distribution of target fish populations. Surveying Salmon Creek and its significant tributaries for coho salmon will evaluate the effectiveness of the CDFG broodstock releases by documenting if the released fish have successfully spawned and ultimately whether the resulting juveniles are able to reestablish a population of wild coho in the watershed. Specific monitoring objectives include estimating spawning success and abundance and survival of juveniles.

Implementation Measures

- Juvenile monitoring employing snorkel surveys during the summer rearing period to determine presence and distribution of juvenile coho salmon within different reaches of the watershed.

- Spawner surveys conducted bimonthly from November through February to document the presence and distribution of live adult salmonids, redds, and salmonid carcasses. This information will be used to determine if adults are returning to and spawning within the watershed and to identify their distribution and preferred spawning habitat. Pit tag scans will be used to differentiate between hatchery and wild fish.
- Coordinate with other monitoring efforts, such as the Russian River coho broodstock monitoring program, CDFG, and NOAA Fisheries, to maximize monitoring data and funding resources; make data applicable to as many assessment and restoration efforts as possible.

5. Streamflow Monitoring

Impacts on summer rearing habitat from regional and local water withdrawals include reduced pool depths, reduced DO levels, and higher water temperatures. Temperatures frequently exceed optimal levels, and DO has been recorded at 1-2 mg/L in pools within the project reaches. Fish become stranded and are unable to seek better habitat when pools become disconnected. The objective of streamflow augmentation projects should be to increase the amount of water available for instream flow, lengthen the period of riffle connectivity within the project reaches, and subsequently improve water quality in the pools during the summer and early fall dry season.

SF Monitoring Recommendation 1: Conduct and implement a streamflow monitoring program that tracks water depth in pools, connectivity of pools, and trends in streamflow.

Scientific Reasoning

Annual variations in rainfall and hydrologic patterns strongly determine streamflow characteristics and water quality conditions. Limited reach-specific physical baseline data exists with which to quantify the effectiveness of streamflow restoration projects. Thus, streamflow data collected during the initial monitoring period of projects, or over a hydrologic cycle of wet and dry years, is unlikely to show definitive or immediate results. This additional monitoring recommendation is presented to collect baseline data and evaluate long-term trends.

Implementation Measures

- Utilize pressure transducers (stage recorders) to continuously monitor variations in water depths in pools associated with riparian water diversion changes. Longitudinal thalweg surveys will be used to relate stage readings to actual pool depths and riffle connectivity.
- Visually assess and document flow over riffles within project reaches and continuous stage sensors. Any implemented streamflow augmentation project should show a trend of later timing of pool disconnection and decreasing number of days pools remain disconnected.
- Maintain at least one long-term streamflow gage in the watershed, including a mainstem Salmon Creek gage in Bodega. As part of the long-term streamflow monitoring program, surveys and discharge measurements should be taken to check and maintain the stage-to-discharge rating curve.

6. Riparian Assessment

Assessing, protecting, and enhancing riparian habitat are stated goals of this watershed management plan. Riparian areas in the watershed will be periodically assessed to measure the achievement of this goal. Restoring and protecting riparian vegetation along streams will improve water quality and instream and riparian habitat and will significantly reduce sediment loading to Salmon Creek and its tributaries from streambank erosion.

RA Monitoring Recommendation 1: Track the abundance and distribution of riparian vegetation at least once every 5 years.

Scientific Reasoning

Numerous riparian corridor restoration studies have been conducted on streams in arid and semi-arid areas incorporating controlled livestock access to riparian areas (Lewis 2002). In most areas, very little else was needed to affect substantial recovery, although rates of recovery vary. Restoring riparian corridors has important benefits for reduction in peak runoff and flood routing. Increased water retention capabilities of soils and presence of perennial and wet meadow grasses retard runoff from upland areas, spreading runoff events over a longer time period and reducing flood peaks. Changes in hydraulic geometry of stream channels associated with riparian recovery (deepening, narrowing) assist in this process of natural runoff management.

Recovery of riparian areas can be greatly accelerated by a judicious planting program using selected successional and climax species. Strategic plantings of various herbaceous and woody species may eliminate the necessity of actively "treating" the entire riparian corridor by acting as seed stock for downstream areas (Circuit Rider Productions, Inc., 1986).

Implementation Measures

- Riparian area assessments will be conducted using high-resolution aerial photography. Stream segments will be coded based on the abundance of vegetation in the riparian zone, approximately 50′ on each side of the stream. This information will be added to an existing riparian assessment GIS data layer. In addition, the GIS data layer will be updated each time a stream segment is stabilized and revegetated.
- In riparian vegetation enhancement and riparian fencing reaches document existing species density and diversity by establishing vegetation transects. Monitor these transects on a 5 to 10 year basis for changes over time and effectiveness of restoration projects.

7. Residual Dry Matter (RDM) Assessment

Grazing management practices influence sheet and rill erosion on rangeland. Overgrazing can result in low RDM, reducing site fertility and infiltration rates and exposing soil to more rainfall, which increases erosion and runoff (Lewis et al. 2005). Treatment for low RDM includes better site preparation, seeding and fertilization, and increased grazing management.

RDM Assessment Recommendation 1: Conduct RDM assessments on priority conservation parcels and increase RDM values by 15% using conservation management measures and practices.

Implementation Measures

- Work with livestock ranches and dairies to update ranch plans and to conduct RDM assessment in order to develop better grazing practices. Conservation-oriented ranch plans will include an inventory of existing resources and resource conditions, operational goals, water quality management issues and objectives, and a prioritized list of projects designed to reduce soil loss and agricultural runoff (USDA 1997).

8. Tracking Land Manure Application

Gold Ridge RCD, in collaboration with UCCE and NRCS, will design and promote the adoption of a manure land application tracking system as part of a larger nutrient budgeting and nutrient management planning program. Soil, vegetation, and manure sampling will be conducted to evaluate nutrient content and fertilization requirements for individual dairies. A land application tracking system will be implemented to record current waste loads applied on a per field basis. Sampling results will be used to calibrate land application rates and timing the following year.

The end goal of these efforts is to have dairy operators quantify and better manage on-farm nutrient production and consumption. Through this process, operators will be able to assess and calculate potential excess nutrient loads and address any nutrient imbalance through export of nutrients from the watershed, composting strategies, or other effective management strategies.

TLM Assessment Recommendation 1: Assist dairy operators in the watershed to better track land application of manure, and to promote application at agronomic rates based on soil, manure and vegetation sampling.

Implementation Measures

- Work with dairies to adopt nutrient budgeting and management planning.
- Develop a manure land application tracking system.
- Document reductions in nutrient concentration along the mainstem of Salmon Creek.

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Guidance at the mouth of Salmon Creek.

Photo Courtesy of Lauren Hammack (PCI)

Salmon Creek Integrated Coastal Watershed Management Plan

June 30, 2010

Developed By:

Gold Ridge Resource Conservation District

PRUNUSKE CHATHAM, INC.

Funding and Oversight Provided By:

Water Boards

Coastal Conservancy

NOAA

RESOURCES AGENCY CALIFORNIA DEPARTMENT FISH&GAME

USDA NRCS

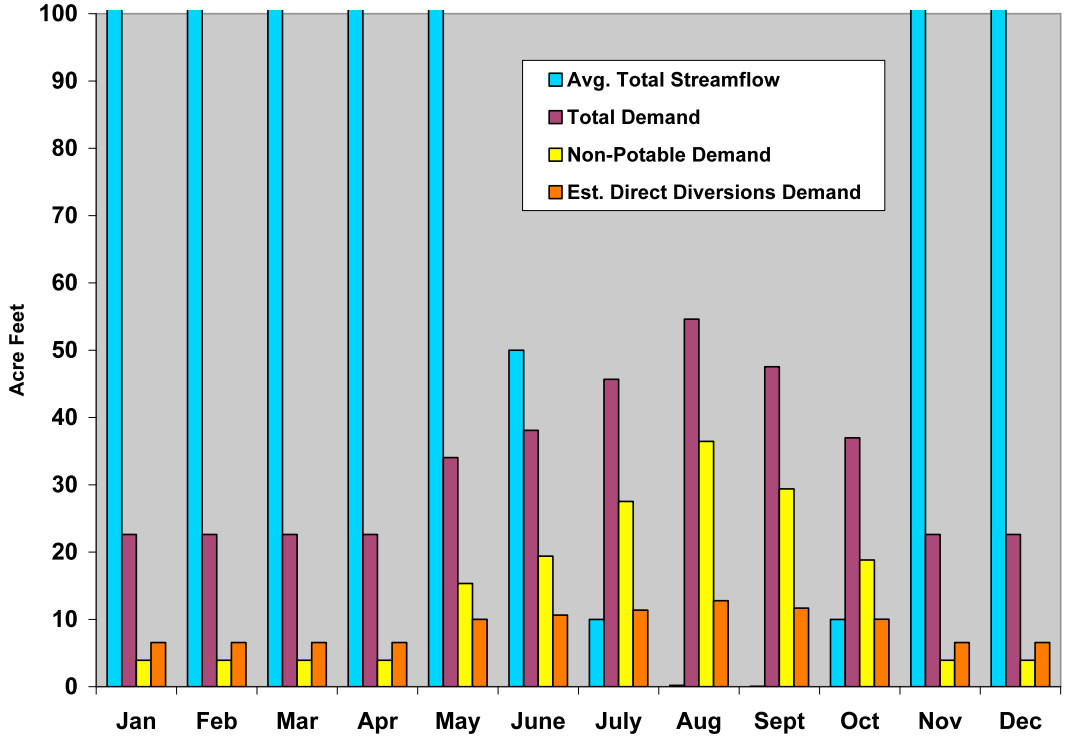
United States Department of Agriculture
Natural Resources Conservation Service

Water Supply Recommendation 1: Develop storage-based water supplies to reduce reliance on, and utilization of, extractive sources.

Scientific Reasoning

Seasonal water scarcity in groundwater and surface water supplies can be offset by storing winter rainfall runoff. Coastal, rural watersheds such as Salmon Creek receive more than enough rainfall to meet the annual water demands of the residents and existing land uses (PCI et al. 2010). Figure 11 illustrates the seasonal cycle of water abundance (winter) and scarcity (summer) as contrasted with the water demand cycles. The seasonal availability disparity can be balanced out—benefiting humans and fish—through the strategic use of storing rainwater in off-channel ponds and roofwater harvesting systems for non-potable irrigation and livestock watering needs. With proper filtration and treatment, roofwater can also be used as a potable water source.

Figure 11. Comparison of water demands in the Salmon Creek Watershed to relative supply, as depicted by streamflow volume.



Source: from PCI et al. 2010.

Estimated late-summer demands on instream sources are 50-200 times greater than streamflow volumes (Figure 11). The direct consumptive uses of instream water in the Salmon Creek Watershed are community water supply wells, livestock watering, summer landscape and garden irrigation, and a small portion of the rural residential use. Capture and storage of winter runoff to replace these direct streamflow withdrawals on a parcel-by-parcel approach could improve instream habitat conditions locally and have significant cumulative effects on summer flows watershed-wide. Replacing all non-potable water demands with stored water would reduce extractive pressures on both the surface water and groundwater supplies and provide greater water security for residents.

Large-scale water storage is not a solution for all water supply concerns and limitations, nor does it mitigate the need for efficient and conservative water use. The impacts of reservoirs on hydrologic flow regimes necessary to maintain ecosystem health have been widely documented (Graff 1999; Richter and Thomas 2007; Grantham et al. 2010). Instream flow regulations for the state of California (AB 2121) are in final draft form and attempt to manage the impacts of water impoundment on streamflow regimes. While it is unlikely that small storage ponds or rainwater catchment systems used to fulfill existing water demands in Salmon Creek would significantly decrease peak runoff during winter storm events, Grantham et al. (2010) suggest that there is an optimal storage capacity for a given watershed that will meet water demands while ensuring critical habitat needs and ecosystem function. Multiple, on-channel storage ponds within a small catchment may reduce early winter base flows and affect salmonid migratory flows.

Water Supply Action 1a: Develop off-channel ponds and distribution systems.

Implementation Measures

- Evaluate agricultural producer's water supply sources to target those using instream or riparian sources.
  - Size systems to cover four (July-Oct.) to six (May-Oct.) months of water demands.
  - Include water distribution systems for livestock use and fence riparian corridors.

Water Supply Action 1b: Install roofwater harvesting systems.

Implementation Measures

- Design and install roofwater catchment systems to replace non-potable water uses from extractive sources and increase water supply security.
  - Size systems to cover four (July-Oct.) to six (May-Oct.) months of water demands.
  - Include water distribution systems for livestock use and fence riparian corridors.
- Consider installing roofwater catchment systems where potable supplies are unreliable, water quality is poor, or water source is a stream diversion.

Water Supply Action 1c: Support landowners in reducing or eliminating use of instream pumps and near-channel wells.

Implementation Measures

- Conduct an education and outreach program to inform residents of the ecological impacts of using their riparian water rights.
  - Provide alternate solutions to riparian water.
  - Low-flow gardening practices.
- Develop off-channel storage and roofwater harvesting systems to replace riparian water sources; see Water Supply Actions 1a and 1b above.
- Develop program to enroll landowners in abstaining from using their riparian rights for the purpose of salmonid habitat improvements.

Salmon Creek Streamflow Restoration Monitoring

2013-2016

Project Monitoring:

Impacts on summer rearing habitat from regional and local water withdrawals include reduced pool depths, reduced dissolved oxygen levels, and higher water temperatures. Fish become stranded and are unable to seek better habitat when pools become disconnected. The objectives of the streamflow restoration projects are to increase the amount of water available for instream flow, lengthen the period of riffle connectivity within the project reaches, and subsequently improve water quality in the pools during the summer and early fall dry season.

The Hughes Dairy project will reduce summer water diversions in the Bodega Valley Reach of Salmon Creek by 7,000 gallons per day (1.27 million gallons over 6 months). The Bodega Water Company Large Storage Tank Project will reduce water diversions of approximately 6,000 gallons per day from mainstem Salmon Creek over the six-month period of June through November of each year (1.1 million gallons over six months). Additional alternative storage and diversion reduction projects in the Bodega Valley Reach replace another 1.32 million gallons. Daily instream diversions from shallow gallery wells replaced by the Bodega Pilot Program will total approximately 14,000 gallons per day. This translates to a flow of 0.02 cubic feet per second, which is enough to keep approximately 0.2 feet of water flowing over the riffles. During a drought year, this will maintain pool habitat quality within the project reach. Historically, during drought years, the withdrawal of these 14,000 gallons per day has caused reach-wide riffle disconnection and localized pool desiccation. Juvenile salmonid mortality has been observed in these circumstances. The Hughes Project, the Bodega Water Company Large Storage Tank Project, and other Bodega Pilot Program streamflow restoration projects, will markedly increase the amount of water available and improve instream habitat within the Bodega Valley.

Project implementation monitoring will be conducted by:

1. Providing an as-built survey and inspection documentation of the water storage system to confirm tank volume and water delivery infrastructure meets design specifications.
2. Increasing the number of locations where water depth and various water quality parameters are continuously monitored from three to five in the Bodega Valley reach.

Ecological effectiveness monitoring will utilize procedures established and implemented in 2010 for the first phase of the Bodega Pilot Program's streamflow restoration implementation projects. Baseline streamflow, pool and riffle depths, and water quality data has been collected in the Bodega Valley Reach since 2010. Water diversions have been metered to track and document summer extractions. Summer streamflow conditions in the reach were visually documented in 2008, the last drought year. While summer streamflow and water quality conditions are driven by complex hydrologic and climatic conditions, which makes it difficult to definitively show habitat-related results from these streamflow restoration projects, tracking

trends over time will provide indicators of project success and important insight into the hydrodynamic processes affecting habitat quality. The habitat indicators to be monitored are streamflow, dissolved oxygen levels in pools, temperature, pool and riffle water depths, and pool connectivity (surface flow over riffles).

Table 1 summarizes the monitoring components, methods, and monitoring schedule. Gold Ridge RCD staff will collect and compile the monitoring data. PCI staff will analyze the data, compare it to previously collected data, and prepare a technical memo at the end of the project period (February 2016) that summarizes the data and results. Data will be displayed graphically and referenced to mapped site locations. An evaluation of project success, as it relates to improvement of key habitat attributes, will be completed where possible.

Table 1. Monitoring strategy

Enhancement Component	Habitat Enhancement Activity	Habitat Parameter Monitored	Monitoring Method	Scale of Measurement	Project Monitoring Schedule	Project Success Criteria	Long-term Programmatic Goals
Streamflow	Low-flow season water diversion reduction. Roofwater harvesting systems to replace non-potable direct diversions.	Pool Depth and Connectivity	Visual observations of riffle connectivity	Spatial: Length of project reach, every riffle to collect baseline data. Temporal: Annually June through Oct, until channel rewatered.	Weekly or as required based on professional judgement.	Reduce direct withdrawals in project reach – Hughes Project estimated 1.27 million gallons per year; Bodega Water Company Project estimated 1.1-1.2 million gallons per year; total Bodega Pilot Program estimated at 2.6 million gallons; actual to be documented at project completion.	Increasing trend in # of days with pools connected
			Pressure transducer to measure pool water depth and downstream riffle connectivity	Spatial: Baseline data collection using three to four in project reach – upstream, adjacent, and downstream of primary diversion(s) Temporal: Annually June thru October pre- and post-project installation	Continuous sampling over monitoring period every 30-minutes Pre-project (2013/4) and Post-project (2015/6)		
		Dissolved Oxygen	Dissolved Oxygen probes stationed in pools to track daily, weekly, and seasonal fluctuations				Increasing trend in # of weeks with average pool DO at or above 7 mg/L
		Temperature	Temperature probes stationed in pools and data used to determine Maximum Weekly Average Temp (MWAT)				Increasing trend in # of weeks with pool MWAT at or below 15°C
		Summer Streamflow	Gage station maintained with pressure transducer, staff plate, and portable weir. Discharge measurements using weir or vertical-axis flow meters.	Spatial: One gage station maintained near downstream end of Bodega Valley Temporal: 10 flow measurements annually during June thru Oct low-flow season to develop rating curve	Continuous sampling over monitoring period every 30-minutes		Increasing trend in summer baseflow discharge and/or drought-period streamflow

The Estero Americano Watershed Management Plan

A Project of the Gold Ridge Resource Conservation District with funding from the State Water Resources Control Board

EROSION & SEDIMENT REDUCTION

Goal

Reduce the Adverse Impacts of Erosion and Sediment from Agricultural Farm Fields

Accelerated erosion on pastureland typically takes two forms: sheet and rill erosion and gully formation. Gullies will often form on land subject to persistent sheet and rill erosion. Grazing management practices can directly influence erosion on rangeland. Intensive grazing can result in low residual dry matter (RDM), reducing site fertility and infiltration rates, and exposing soil to more rainfall—increasing erosion and runoff. Treatment for low RDM includes better site preparation, seeding and fertilization, and increased grazing management. Identifying and treating gullies with the highest potential sediment yield that are connected to a surface waterbody will reduce annual sediment loads to the estuary and its tributaries.

Reduce the Adverse Impacts of Erosion and Sediment from Unstable Streambanks

The condition of a stream channel—its morphology, sediment distribution, and associated habitat value—is often a direct reflection of the density and diversity of the riparian plant community and upland vegetative cover. Streambank erosion is associated with the removal of riparian vegetation and bank trampling resulting from livestock access. Revegetating stream corridors and controlling livestock access will significantly reduce streambank erosion.

Reduce the Adverse Impacts of Erosion and Sediment from Private and Public Roads

Road surfaces, cut and fill slopes, and ditches are common sources of sediment in the watershed. Failures of road crossing fills or cut and fill slopes produce episodic sediment runoff, usually during large precipitation events. Better road maintenance, design and upgrading of ranch roads will reduce chronic sediment loading to the estuary and its tributaries.

Improperly sized and maintained culverts under county and state highways are a common problem in the watershed, causing increased debris jams, streambank erosion, and local flooding. Better maintenance and design of public road networks will help to reduce sediment impacts to surface waterbodies as well as enhance aquatic habitat conditions in the watershed.

Actions

Conduct an assessment to identify areas of low, medium, and high RDM on rangeland in the watershed by 2010.

Identify and implement priority infrastructure improvements for better grazing management practices such as cross-fencing, off-channel water development, livestock crossings and walkways, filter strips and drainage diversions around heavy use areas by 2010.

Design, permit, and implement stream channel stabilization projects, and revegetate stream corridors identified in this management plan (ongoing).

Select a ranch to function as a demonstration project for grazing best management practices in the watershed. Use the program to educate other agricultural producers in the watershed and the region, and to promote new and on-going participation in NRCS's Environmental Quality Incentives Program (EQIP) by 2010.

Restore or mitigate erosion from a minimum of 8 gullies in the watershed by 2010.

Enhance rangeland and pasture on livestock ranches and dairy operations in the watershed to reduce streambank erosion and sheet and rill erosion (ongoing).

Upgrade 30 miles of ranch roads in the watershed by 2010.

Improve county and state road maintenance practices.

STATE OF CALIFORNIA RESOURCES AGENCY DEPARTMENT OF FISH AND GAME

Recovery Strategy for California Coho Salmon

Report to the California Fish and Game Commission

PREPARED BY
The California Department of Fish and Game

Species Recovery Strategy 2004-1

FEBRUARY 2004

The major freshwater habitats used by each life stage of coho salmon are identified in Table 2-2. Table 2-3 summarizes essential habitat elements by life stage and for each element shows the range of suitability necessary for the viability and survival of coho salmon.

TABLE 2-2: Freshwater habitats of the different life stages of coho salmon

FRESHWATER HABITAT	COHO SALMON LIFE STAGE
Flat water riffle	fry, juveniles, spawning adults
Flat water	juveniles, spawning adults
Gravel streambed	eggs, alevins, young fry, spawning adults
Pool	fry, juveniles, migrating adults
Side-channel	fry, juveniles
Stream bank	fry, juveniles
Submerged vegetation and LWD	juveniles

2.7.4.1 Stream Vegetation

Vegetation in the riparian corridor provides many essential benefits to stream conditions and habitat. It serves as a buffer from sediment and pollution, influences the geomorphology and stream flow, and provides stream-bank stability. Vegetation adjacent to the water stabilizes the stream bank. The riparian buffer is vital to moderating water temperatures that influence spawning and rearing by providing the canopy, which protects the water from direct insolation, and the buffer, which provides a cooler microclimate and lower ambient temperatures near the stream. The riparian canopy also serves as cover from predators, and supplies both insect prey and organic nutrients to streams.

2.7.4.2 Large Woody Debris

LWD is an essential component with several ecological functions. Within the estuarine environment, it stabilizes substrate, provides cover from predators, and provides shelter. In the freshwater environment, it serves these same functions as well as providing for pool establishment and maintenance, spawning bed integrity, habitat for aquatic invertebrate prey, and instream productivity.

2.7.4.3 Sediment and Substrate

The channel substrate type and size, and the quantity and distribution of sediment have essential direct and indirect functions at several life stages of coho salmon. Adults require gravel of appropriate size and shape for spawning, building redds, and laying eggs. Eggs develop and hatch within the substrate, and alevins remain there for some time for protection and shelter. The substrate also functions as habitat for rearing juveniles by providing shelter from faster flowing water and protection from predators. Also, some invertebrate prey inhabit the benthic and epibenthic environment of the stream substrate. An excess of fine sediment is a significant threat to eggs and fry because it can: 1) reduce the interstitial flow necessary to regulate water temperature and DO, remove excreted waste, and provide food for fry; 2) reduce available habitat; and 3) envelop, and then suffocate, eggs and fry. The flushing and cycling of fine sediments is paramount to coho salmon survival.

2.7.4.4 Hydrological Regime

The characteristics of the water and the geomorphology of the stream channel are fundamentally essential to all coho salmon life stages that inhabit coastal watersheds. Important charac-

TABLE 2-3: Fundamental habitat elements and suitable ranges for coho salmon life stages[a]

ELEMENT	LIFE STAGE	SUITABLE RANGE	REFERENCE OR CITATION
Large woody debris	rearing juvenile	>400 ft^3/100 ft reach[b]	Murphy 1995
Riparian cover	rearing juvenile	>80%	Flosi et al. 1998
Sediment and substrate	spawning adult	20% fine sediment; 0.51-4.02 inches (size)[c]	Reiser and Bjornn 1979; Bjornn and Reiser 1991
	egg and fry	depth: 7.01-15.41 in; ~9.85 in; diameter: 1.54-5.40, ~3.70; <20% fine; <12% fine, <5% fine (optimum)	Briggs 1953; Cederholm and Reid 1987; PFMC 1999
Stream flow (peak flow, freshets, minimum summer flow)	migrating adult	discharge is specific to stream	
	spawning adult	discharge is specific to stream	
	rearing juvenile	discharge is specific to stream	
Territory (square feet)	spawning pair	126	Bjornn and Reiser 1991
	rearing juvenile	26-59/fish; 0.001-1.0 fish per 3.281 [0.5-1 year old]	Reiser and Bjornn 1979; Bjornn and Reiser 1991
Turbidity (NTU[d])	migrating adult	<30 ounces/gal	Bjornn and Reiser 1991
	spawning adult	clear to heavily silted	Sandercock 1991
	juvenile	>60 (disrupted behavior); >70 (avoidance)	Bjornn and Reiser 1991
Water depth (inches)	migrating and spawning adult	4.02-7.88; ~6.19; 7 (minimum)	Briggs 1953; Bjornn and Reiser 1991
	rearing juvenile[e]	9.46-48.07	Bjornn and Reiser 1991
Dissolved oxygen (oz/gal)	migrating adult	‡80% saturation and >0.037	Bjornn and Reiser 1991
	rearing juvenile	100% saturation (preferred); 0.037-0.044 (stressed); >.059 (optimum)	Reiser and Bjornn 1979; Bjornn and Reiser 1991, PFMC 1999
	egg and fry	near saturation (preferred); >0.059 (optimum)	Reiser and Bjornn 1979; Bjornn and Reiser 1991; PFMC 1999
Water temperature (°F)	migrating adult	44.6-59	Reiser and Bjornn 1979
	spawning adult	39.2-48.2	Bjornn and Reiser 1991
	rearing juvenile	35 (lower lethal); 78.8-83.8 (upper lethal); 53.6-57.2 (optimum); 48-59.9 (optimum); 63.7-64.9 (MWAT[f]); 62.1 (MWAT) and 64.4 (MWMT[g])	Bjornn and Reiser 1991; Flosi et al. 1998; Ambrose et al. 1996; Ambrose and Hines 1997, 1998; Hines and Ambrose ND; Welsh et al. 2001
	egg and fry	39.2-51.8; 39.2-55.4 (optimum); 32-62.6	Davidson and Hutchinson 1938; Bjornn and Reiser 1991, PFMC 1999
Water velocity (ft/s)	migrating adult	<8	Reiser and Bjornn 1979
	spawning adult	0.98-2.46; 1.02; 1.9, 0.98-2.99	Briggs 1953; Reiser and Bjornn 1979; Bjornn and Reiser 1991
	rearing juvenile	0.30-0.98 (preferred for age 0), 1.02-1.51 (riffle), 0.30-0.79 (pool); 0.16-1.283; 0.16-0.98	Reiser and Bjornn 1979; PFMC 1999
	egg and fry	0.82-2.95	PFMC 1999

NOTES:

[a] Values presented in this table are based on general conditions found within suitable coho salmon habitat in California and elsewhere. Individual determinations of habitat suitability and restoration potential should be based on site-specific conditions in consultation with the Department.

[b] Coho salmon research conducted in southeast Alaska.

[c] Estimated from other species or general for anadromous salmonids.

[d] NTU = Nephelometric Turbidity Units

[e] Various sizes and ages. Fish either aged (0 or 1) or measured (15.8-24.4 cm).

[f] MWAT = Maximum weekly average temperature

[g] MWMT = Maximum weekly maximum temperature

RW-V-E-03 Continue to fund and support the CalTIP program. Provide additional training for Wardens to identify water pollution problems and promote coordination with other responsible agencies. Coordinate water rights training for resource agency personnel.

7.5 SEDIMENTS

RW-VI-A-02 Identify and prioritize specific sediment source locations for treatment that may deliver sediment to coho salmon streams. Encourage the use of protocols, such as the California Stream Habitat Restoration Manual Guidelines. Work with others to educate and provide technical assistance to landowners to implement upgrades.

RW-VI-B-01 Encourage agencies and landowners to restore natural drainage patterns and minimize hydrologic connectivity of roads, where feasible. Encourage funding agencies to provide annual funding for implementation of the program.

RW-VI-B-02 Continue to fund and provide technical support to local government and private landowner actions to reduce identified sediment input from upslope sources. Basin-wide assessments should prioritize remediation activities, which would include slope stabilization and minimizing sediment production.

RW-VI-D-01 Encourage Federal, State, and county agencies and private landowners to reduce impacts to coho salmon habitat from public and private road systems. Continue road and/or watershed assessments to identify and prioritize sources and risks of road-related sediment delivery to watercourses. Support activities to:

a. Reduce road densities where necessary and appropriate;
b. Upgrade roads and road-maintenance practices to eliminate or reduce the potential for concentrating run-off to streams during rainfall events. Employ best available technology when appropriate;
c. Encourage measures to reduce sediment delivery from unpaved roads;
d. Decrease potential for streamflow to become diverted at road crossings during high flow events, resulting in flow along the road that returns to the channel at undesirable locations;
e. Stabilize slopes to minimize or prevent erosion and to minimize future risk of eroded material entering streams;
f. Minimize alteration of natural hill slope drainage patterns; and
g. Encourage funding authorities to allocate adequate budgets to Federal, State, and local agencies and private landowners for road maintenance activities, capital project activities, and dedicated funding to pay for fish passage projects.

7.6 WATER TEMPERATURE

RW-X-B-01 Identify and implement actions to maintain and restore water temperatures to meet habitat requirements for coho salmon in specific streams.

RW-X-B-02 Offer funding and permit incentives to restore stream habitat where lack of LWD, riparian cover, simplified stream morphology and other conditions have been determined to be limiting factors to coho salmon habitat.

7.7 LARGE WOODY DEBRIS

RW-XII-B-01a Identify those riparian vegetation communities that provide good opportunities for conifer LWD recruitment to coho salmon habitat. Communicate the importance of these riparian communities to appropriate agencies, restoration funding groups, and landowners, and work to maintain them in a healthy condition. Address and identify possible solutions to potential conflicts between flood management activities and maintenance of riparian vegetation and large woody debris.

RW-XII-B-01b Prioritize riparian vegetation communities for the purposes of restoring conifer LWD recruitment.

RW-XII-B-02 Funding authorities should provide funding and technical support for riparian restoration.

RW-LW-07 Encourage management practices that promote conifer recruitment to provide short-term and long-term restoration of LWD and stream shade.

RW-LW-08 Encourage Federal, State, and county agencies and private landowners to protect instream LWD to the greatest extent practicable without endangering public safety, life or property.

7.8 STREAM COMPLEXITY

RW-XIII-C-01 Modify channel or flood control maintenance manuals for consistency with habitat requirements and protection for coho salmon.

RW-XIII-C-02 Where appropriate and feasible, work with all parties, including landowners, to reconfigure levees and channelized streams to benefit coho salmon.

7.9 REFUGIA

RW-XV-A-01 Identify key coho salmon refugia and inform land managers and other agencies of their locations and characteristics.

RW-XV-A-02 Identify core coho salmon populations, inform land managers and other agencies of their locations, and implement measures to maintain those populations.

RW-XV-B-01 Maintain or re-establish geographic distribution of coho salmon by continuing to allocate substantial improvement efforts towards identified key refugia with substantial coho salmon populations and/or otherwise suitable conditions.

RECOVERY PLAN

FOR THE EVOLUTIONARILY SIGNIFICANT UNIT OF CENTRAL CALIFORNIA COAST COHO SALMON

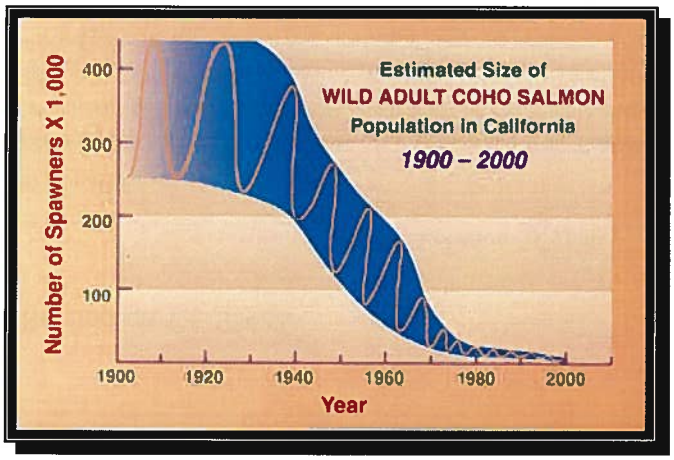


Photo Courtesy: CCC coho salmon, Morgan Bond, SWFSC
Conceptual Model of the Extinction Vortex for California's Coho Salmon, Peter Moyle 2009

PUBLIC DRAFT

Version: March 2010
Southwest Regional Office
National Marine Fisheries Service
Santa Rosa, CA

Salmon Creek

Location	•Sonoma County
Watershed Area	•35.0 Square Miles
Potential Habitat	•35.9 Stream Miles
Vegetation	•42% Coniferous or Montane Forest, 42% Grassland
Erodability	•Low to Moderate
Ownership Patterns	•99% Private
Dominant Land Uses	•Ranching
Housing Density	•Low
TMDL Pollutants	•None

Salmon Creek
Photo by Michael Fawcett

Salmon Creek Coho Salmon: Nearly Extirpated

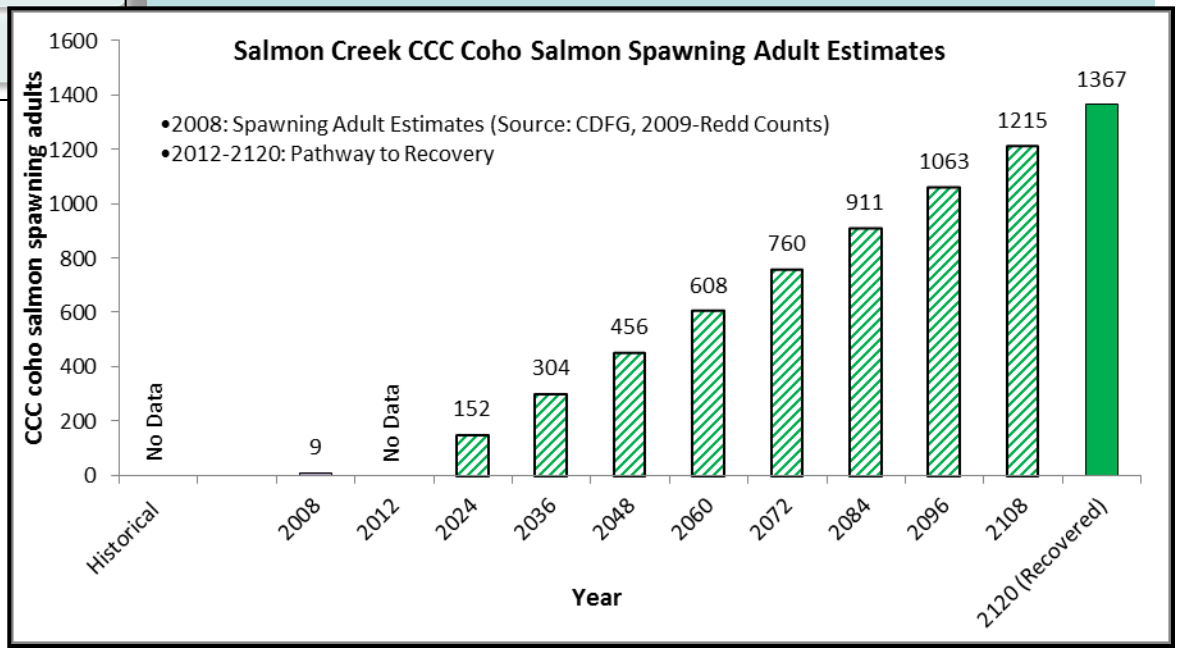
Recovery Goals

- ✓ Continue the operation of the Captive Broodstock Program in Salmon Creek
- ✓ Conduct monitoring to track population response to recovery action implementation

Salmon Creek
Adult Spawner Targets

Downlisting to Threatened
684

Recovery
1,367



STEELHEAD: YES
CHINOOK SALMON: NO

4.1.1. **Recovery Action:** Improve flow conditions (baseflow conditions)

4.1.1.1. **Action Step:** Develop rearing habitat curves to identify optimal base flow conditions

4.1.1.2. **Action Step:** Promote, via technical assistance and/or regulatory action, the reduction of water use affecting the natural hydrograph, development of alternative water sources, and implementation of diversion regimes protective of the natural hydrograph.

4.1.1.3. **Action Step:** Avoid and/or minimize the adverse effects of water diversion on coho salmon by establishing: a more natural hydrograph, by-pass flows, season of diversion, and off-stream storage (BM-HU-04 in CDFG 2004).

4.1.2. **Recovery Action:** Improve flow conditions (instantaneous conditions)

4.1.2.1. **Action Step:** Reduce the rate of frost protection and domestic drawdown in the spring

4.2. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

4.2.1. **Recovery Action:** Improve flow conditions (baseflow conditions)

4.2.1.1. **Action Step:** Develop cooperative projects with private landowners to conserve summer flows

4.2.1.2. **Action Step:** Support the water conservation training conducted by the Occidental Arts and Ecology Center Water Institute, Gold Ridge RCD, and Salmon Creek Watershed Council.

4.2.2. **Recovery Action:** Minimize redd scour

4.2.2.1. **Action Step:** Develop floodplain enhancement and LWD projects in modified and incised channel areas of major tributaries

5. Restoration- Landscape Patterns

5.1. **Objective:** Address the inadequacy of existing regulatory mechanisms

5.1.1. **Recovery Action:** Prevent increased landscape disturbance

5.1.1.1. **Action Step:** Utilize BMP's which prevent fracturing of landscapes and interruption of natural function in forested watersheds, riparian corridors, and stream systems

5.1.1.2. **Action Step:** Avoid new development, or road construction within floodplains, riparian areas, unstable soils or other sensitive areas

5.1.1.3. **Action Step:** Conserve open space in un-fractured landscapes, protect floodplain areas and riparian corridors, and develop conservation easements

5.2. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

5.2.1. **Recovery Action:** Conserve water resources

5.2.1.1. **Action Step:** Residential landowners should utilize BMP's from Basins Of Relations: A Citizen's Guide to Protecting and Restoring Our Watersheds (OAEC, 2007), Slow it. Spread it. Sink it! (Santa Cruz Resource Conservations District, 2009) to conserve water resources

Russian River

Location	• Mendocino and Sonoma Counties
Watershed Area	• 1,483.0 Square Miles
Potential Habitat	• 457.5 Stream Miles
Vegetation	• 12% Coniferous, 40% Montane Hardwood, 18% Grassland, 13% Agricultural
Erodability	• Moderate to High
Ownership Patterns	• 99% Private
Dominant Land Uses	• Urbanization, Agriculture, Ranching, Gravel Mining
Housing Density	• Moderate to High
TMDL Pollutants	• Sediment, Temperature, Nutrients, Pathogens, Metals

Russian River
Photo by Joe Pecharich

Russian River Coho Salmon: Nearly Extirpated

Recovery Goals

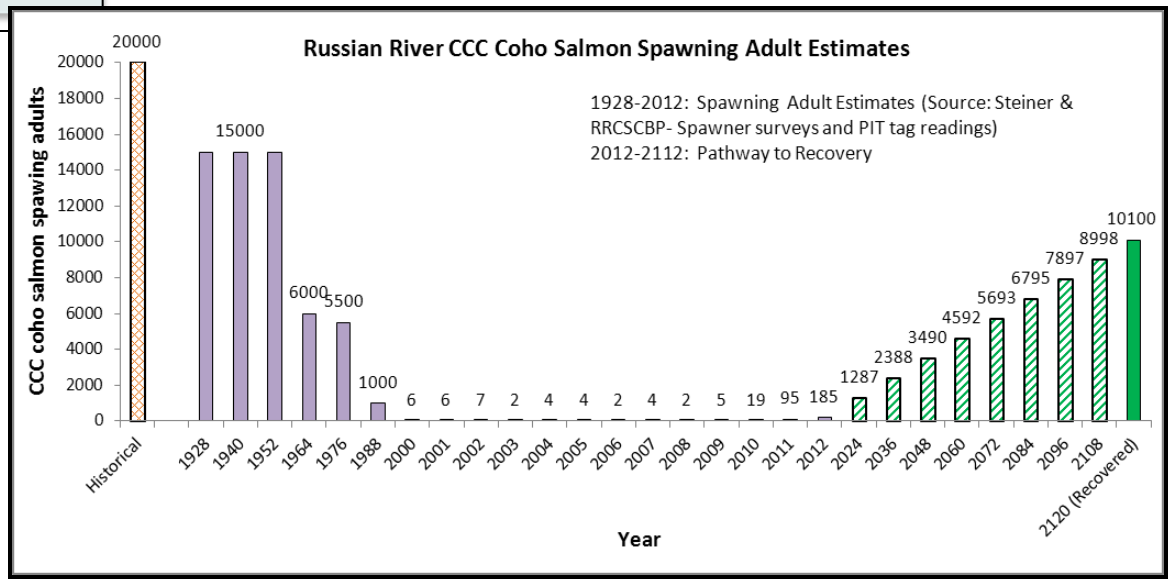
- ✓ Continue and expand captive broodstock program
- ✓ Encourage establishment and use of conservation banks
- ✓ Expand fish and habitat monitoring programs
- ✓ Increase enforcement and outreach and education to prevent take

Russian River Adult Spawner Targets

Downlisting to Threatened 5,050

Recovery 10,100

STEELHEAD: YES
CHINOOK SALMON: YES



2.2.2.2. **Action Step:** Evaluate the potential to reconstruct historic lakes in northern Laguna de Santa Rosa, upstream of the confluence of Laguna Channel & Mark West Creek to enhance overwintering habitat and to improve passage opportunities for upstream migration during dry winters; plant riparian tree species around ponds; debris removal

3. Restoration- Habitat Complexity

3.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

3.1.1. **Recovery Action:** Increase large wood frequency (BFW 0-10 meters)

3.1.1.1. **Action Step:** Increase large wood frequency to 75% of streams within the watershed to improve conditions for adults, and winter/summer rearing juveniles

3.1.1.2. **Action Step:** Increase LWD frequency to optimal conditions (>6 key LWD pieces/100 meters) in all reaches of Green Valley, Purrington, Atascadero, Redwood, Jonive, Castellini and Sexton Creeks

3.1.1.3. **Action Step:** Increase LWD frequency to optimal conditions (>6 key LWD pieces/100 meters) in select reaches of Bearpen, Black Rock, Kidd, Kohute Gulch, Clear, Pole Mtn, Blue Jay, Tiny, and Holmes Canyon Creeks

3.1.1.4. **Action Step:** Increase LWD frequency to optimal conditions (>2 key LWD pieces/100 meters) in select reaches of Austin and Ward Creeks

3.1.1.5. **Action Step:** Increase LWD frequency to optimal conditions (>6 key LWD pieces/100 meters) in select reaches of Mark West, Dry, and Maacama Creeks

3.1.2. **Recovery Action:** Increase frequency of primary pools

3.1.2.1. **Action Step:** Increase pool frequency to 75% of streams within the watershed to improve conditions for adults, and summer/winter juveniles

3.1.2.2. **Action Step:** Increase primary pool frequency to achieve optimal conditions (>40% of pools meet primary pool criteria (>2.5 feet deep in 1st and 2nd order streams; >3 feet in third order or larger streams)) in all reaches of Purrington, Atascadero, and Castellini Creeks

3.1.2.3. **Action Step:** Increase primary pool frequency to achieve optimal conditions (>40% of pools meet primary pool criteria (>2.5 feet deep in 1st and 2nd order streams; >3 feet in third order or larger streams)) in select reaches of Austin, Bear Pen, Black Rock, Blue Jay, Conshea, Devils, Gray, Holmes Canyon, Kidd, Kohute Gulch, Pole Mtn, and Schoolhouse Creeks

3.1.2.4. **Action Step:** Increase primary pool frequency to achieve optimal conditions (>40% of pools meet primary pool criteria (>2.5 feet deep in 1st and 2nd order streams; >3 feet in third order or larger streams)) in select reaches of Dry, Maacama, and Mark West Creeks

3.1.2.5. **Action Step:** Install or enhance existing LWD, boulders, and other instream features to increase habitat complexity and improve pool frequency and depth (CDFG 2004). Priority streams include Redwood Creek, Foote Creek, Kellogg Creek, and Yellowjacket Creek.

3.1.2.6. **Action Step:** Where feasible, increase woody cover in the pool and flatwater habitat units throughout the Mark West watershed, focusing on a combination of cover/scour structures constructed with boulders and woody debris within flatwater and pool locations. Work should be done in conjunction with stream bank stabilization to prevent erosion (CDFG habitat inventory reports).

3.1.3. **Recovery Action:** Improve shelter rating

3.1.3.1. **Action Step:** Increase shelter ratings to 75% of streams across the watershed to improve conditions for adults, and winter/summer rearing juveniles

3.1.3.2. **Action Step:** Increase shelter ratings to optimal conditions (>80 pool shelter value) in all reaches of Green Valley, Purrington, Atascadero, Redwood, Jonive, Castellini and Sexton Creeks

3.1.3.3. **Action Step:** Increase shelter ratings to optimal conditions (>80 pool shelter value) in select reaches of Austin, Bearpen, Black Rock, Kidd, Kohute Gulch, Clear, Ward, Pole Mtn, Blue Jay, Tiny, and Ward Creeks and Holmes Canyon Creeks

3.1.3.4. **Action Step:** Increase shelter ratings to optimal conditions (>80 pool shelter value) in select reaches of Dry, Mark West and Maacama Creeks

3.1.3.5. **Action Step:** Increase shelter rating on the following streams : tributaries of and including Dry Creek, Forsythe Creek, Willow Creek, Sheephouse Creek, Porter Creek, Dutch Bill Creek, Redwood Creek, Foote Creek, Kellogg Creek, Wine Creek and Yellowjacket Creek.

3.1.4. **Recovery Action:** Improve pool/riffle/flatwater ratios (hydraulic diversity)

3.1.4.1. **Action Step:** Increase the frequencies to 75% of the streams within the watershed

3.1.4.2. **Action Step:** Increase riffle frequency to 20% by converting flatwater habitats (glides, runs, etc.) utilizing boulders and log structures in select reaches of Green Valley, Atascadero, Jonive, Castellini and Sexton Creeks

3.1.4.3. **Action Step:** Increase riffle frequency to 20% by converting flatwater habitats (glides, runs, etc.) utilizing boulders and log structures in select reaches of Austin Creek.

3.1.4.4. **Action Step:** Increase riffle frequency to 20% by converting flatwater habitats (glides, runs, etc.) utilizing boulders and log structures in select reaches of Mark West, Dry and Maacama Creeks

3.2. **Objective:** Address other natural or manmade factors affecting the species' continued existence

3.2.1. **Recovery Action:** Improve Habitat Complexity

3.2.1.1. **Action Step:** Investigate the feasibility of beaver re-location and re-introductions to Sonoma (specifically Austin, Green Valley, lower Russian River independent populations and Salmon Creek) to promote channel complexity, improve baseflows and provide rearing habitat

4. Restoration- Hydrology

24.1.1.2. **Action Step:** Land use zoning should be appropriate to the site and be tolerant to anticipated conditions (e.g., tolerant to frequent flooding).

24.1.1.3. **Action Step:** Work with local governments to incorporate protection of CCC coho salmon in any flood management activity (CDFG 2004).

24.2. **Objective:** Address the present or threatened destruction, modification, or curtailment of the species habitat or range

24.2.1. **Recovery Action:** Prevent impairment to hydrology

24.2.1.1. **Action Step:** Minimize water use and seek alternatives during droughts.

24.2.1.2. **Action Step:** Work with land owners or public agencies to acquire water that would be utilized to minimize effects of droughts.

24.2.1.3. **Action Step:** Pursue opportunities to acquire or lease water, or acquire water rights from willing sellers, for coho salmon recovery purposes. Develop incentives for water right holders to dedicate instream flows for the protection of coho salmon (CDFG 2004)(Water Code § 1707).

24.2.2. **Recovery Action:** Prevent impairment to water quality (impaired instream temperature)

24.2.2.1. **Action Step:** Maintain canopy levels at desirable levels in all streams and restore canopy levels to desirable levels in high value habitat areas (See WATER QUALITY for specific actions/areas

25. Threat- Water Diversion/Impoundment

25.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

25.1.1. **Recovery Action:** Prevent impairment to stream hydrology (impaired water flow)

25.1.1.1. **Action Step:** Promote the use of reclaimed water for agricultural or other uses.

25.1.1.2. **Action Step:** Promote water conservation by the public, water agencies, agriculture, private industry, and the citizenry.

25.1.1.3. **Action Step:** Promote off-channel storage to reduce impacts of water diversion (e.g., storage tanks for rural residential users).

25.1.1.4. **Action Step:** Provide incentives to water rights holders willing to convert some or all of their water right to instream use via petition change of use and §1707 (CDFG 2004).

25.1.1.5. **Action Step:** Improve coordination between agencies and others to address season of diversion, off-stream reservoirs, bypass flows protective of coho salmon and their habitats, and avoidance of adverse impacts caused by water diversion (CDFG 2004).

25.1.1.6. **Action Step:** Promote passive diversion devices designed to allow diversion of water only when minimum streamflow requirements are met or exceeded (CDFG 2004).

25.1.1.7. **Action Step:** Promote the use of reclaimed water for agricultural or other uses.

2000

CALIFORNIA DEPARTMENT OF FISH AND GAME
STREAM INVENTORY REPORT
Dutch Bill Creek

INTRODUCTION

A stream inventory was conducted during the summer of 1997 on Dutch Bill Creek. The inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the amount and condition of available habitat to fish, and other aquatic species with an emphasis on anadromous salmonids in Dutch Bill Creek. The objective of the biological inventory was to document the salmonid and other aquatic species present and their distribution.

The objective of this report is to document the current habitat conditions, and recommend options for the potential enhancement of habitat for coho salmon and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Dutch Bill Creek is a tributary to the Russian River , located in Sonoma County, California (see Dutch Bill Creek map, page 2). The legal description at the confluence with the Russian River is T7N, R10W,S7. Its location is 38°27'56" N. latitude and 123°00'32" W. longitude. Year round vehicle access exists from Highway 101 taking Highway 12 West, via Bodega Hwy. to Bohemian Hwy., through the town of Occidental (headwaters), to the town of Monte Rio (mouth).

Dutch Bill Creek and its tributaries drain a basin of approximately 11.6 square miles. Dutch Bill Creek is a third order stream and has approximately 9.0 miles of blue line stream, according to the USGS Duncan Mills and Camp Meeker 7.5 minute quadrangles. Major tributaries included in this report are: Tyrone Gulch, Crawford Gulch, Duvoul Creek, Grub Creek,

GENERAL RECOMMENDATIONS

Dutch Bill Creek should be managed as an anadromous, natural production stream.

Shortly before the survey, winter storms brought down many large trees and other woody debris into the stream, which increased the number and quality of pools since drought years. This woody debris, if left undisturbed, would have provided fish shelter and rearing habitat, and offset channel incision. Recently, many logs were removed by flood control crews and historic tree and log removal were evident in the active channel during our survey. Efforts to increase flood protection or improve fish access in the short run, have led to long term problems in the system. Landowners should be sensitive and the city should be educated about the natural and positive role woody debris plays in the system, and encouraged not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

SPECIFIC FISHERY ENHANCEMENT RECOMMENDATIONS

1) Access for migrating salmonids is an ongoing potential problem, therefore, fish passage should be improved where possible. Baffles should be installed in several tributary culverts to facilitate easier fish access.

2) Where feasible, increase woody cover in the pool and flatwater habitat units along the entire stream. Most of the existing shelter is from vegetation and undercut banks. Adding high quality complexity with larger woody cover is desirable. Combination cover/scour structures constructed with boulders and woody debris would be effective in many flatwater and pool locations in all the reaches. Where feasible, design and engineer pool enhancement structures to increase the length and depth of pools in all reaches. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion.

3) In Dutch Bill Creek, active and potential sediment sources related to the County road system need to be improved, and treated according to their potential for sediment yield to the stream and its tributaries. Maintenance of ditches,

culverts, and inboard cutbank slides should be improved to decrease the potential of sediment delivery to Dutch Bill Creek. During storms, surface runoff over the road causes outboard cutbank slides, delivering sediment and threatening the road integrity. This is primarily due to the existing conditions of the road drainage network

.4) Spawning gravels on Dutch Bill Creek are limited to relatively few reaches. Structures to decrease channel incision and recruit spawning gravel (using gravel retention structures), should be installed to trap, sort and expand redd distribution in the stream (particularly on Dutch Bill Creek Reaches 3-7)

5) Map sources of upslope and in-channel erosion, and prioritize them according to present and potential sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream. Near-stream riparian planting along any portion of the stream should be encouraged to provide bank stability and a buffering against urban runoff.

6) Access for migrating salmonids is an ongoing potential problem, therefore, fish passage should be monitored before and after improvements of culverts.

RESTORATION IMPLEMENTED

1) The fish ladder at Reach 3 should be improved to pass fish easier at all flows.

Business Plan for the Russian River Coho

March 24, 2009

NFWF Russian River Coho Biz Plan.indd 1 8/12/09 11:54:27 AM

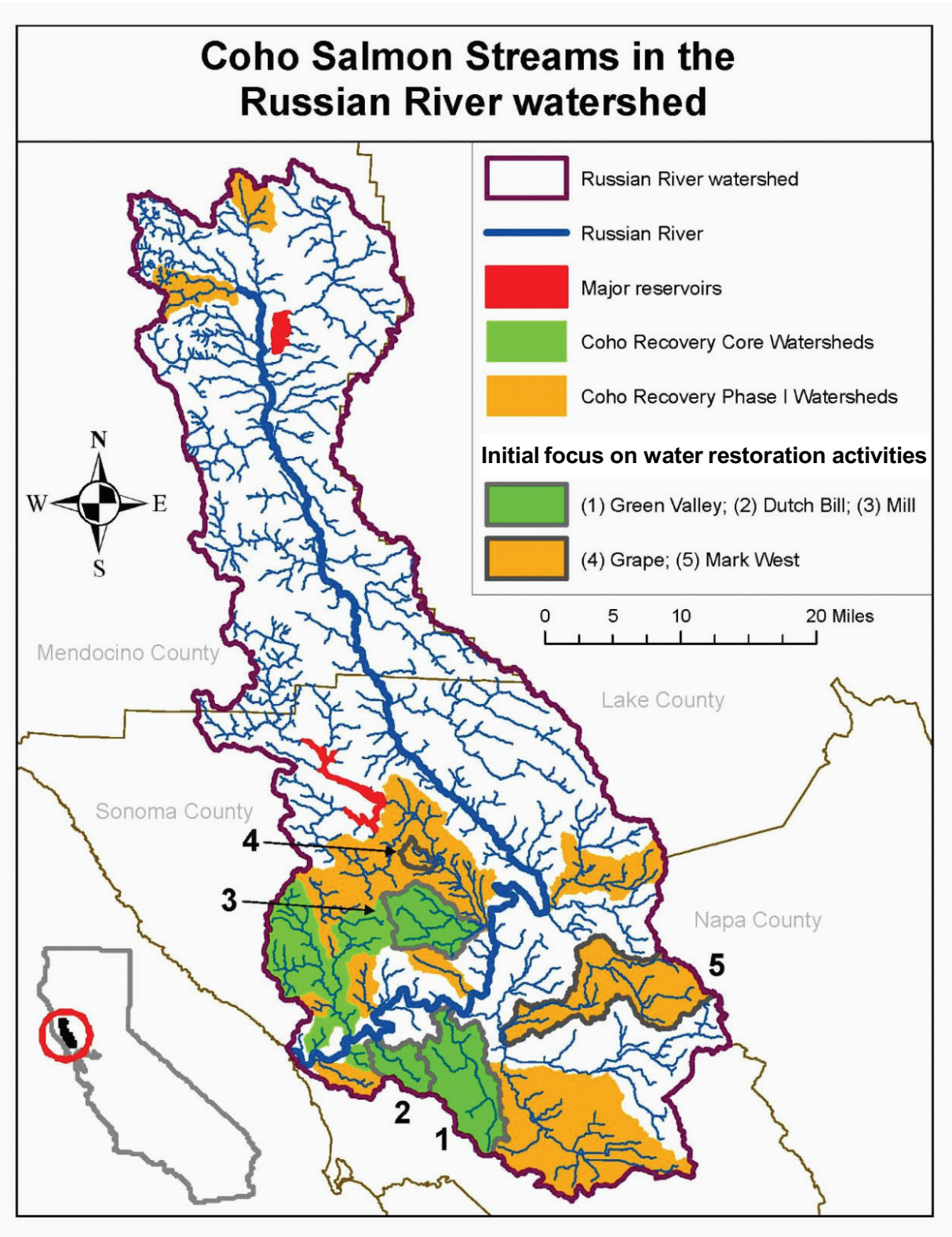


Figure 3. Core and Phase I watersheds (as identified by the National Marine Fisheries Service Coho Recovery Plan) that are essential for coho recovery in the Russian River watershed; and specific watersheds (numbered 1-5) for which restoration activities must focus on restoring an adequate hydrologic regime. (See Appendix for more details about existing and proposed habitat restoration in coho watersheds.)

regulatory agencies. If the previous activities are completed successfully, mitigating these risks will be much easier. Also, the technical infrastructure must be created to communicate water levels and diversion operation instantaneously to ensure that diversions operate in compliance with management plans. For example, if the management plan relies on a group of landowners to coordinate wintertime diversions to meet designated instream flow thresholds, governance tasks might include defining the organization that would manage the stream gauges, funding sources, permit reporting, and dispute resolution.

Key Strategy 2 — Riparian/instream habitat restoration, conservation, and augmentation (R/C/A).

Human development and land use practices in the Russian River watershed have also frequently resulted in altered stream channels, reduced riparian zones, and reduced access to suitable spawning habitat. Streambank alterations have resulted in a loss of natural habitat complexity (i.e., riffles, pools, and other *refugia*), effectively limiting the capacity for freshwater streams to serve as spawning, rearing, and migratory habitat for a viable coho salmon population. The removal of riparian vegetation has caused increases in temperature, fine sediment, and toxins that impair coho productivity and survival, as well as reduced instream complexity as a result of fewer sources of large woody debris. Effective restoration will address both impaired habitat functions and habitat forming processes, and it will protect those habitats that presently function well.

Activities designed to address this Key Strategy may include, but are not limited to:

A. Riparian enhancement projects, which include developing enhancement plans and executing revegetation activities. Riparian enhancement improves riparian zone function, which can improve water quality and increase instream habitat complexity.

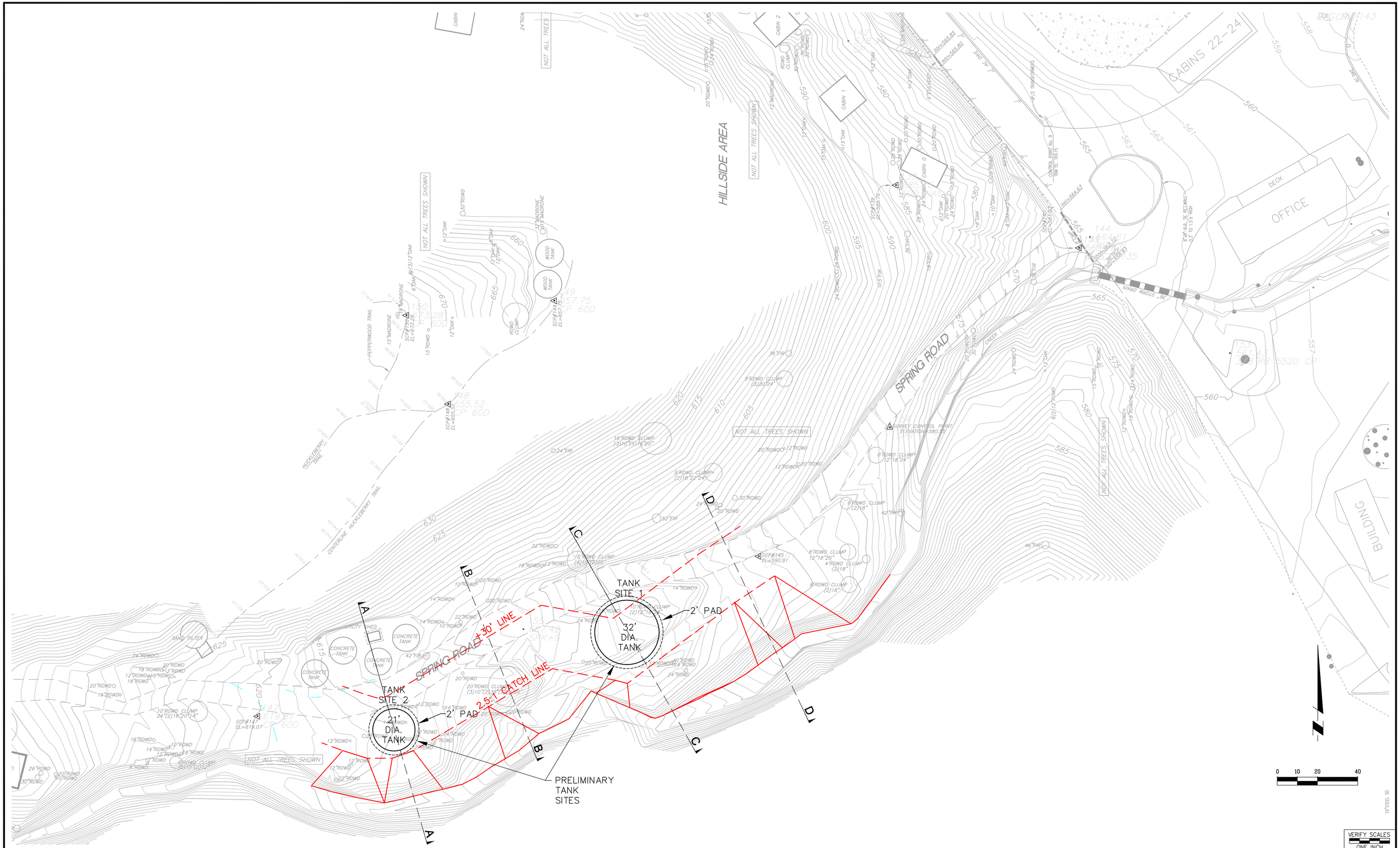
B. Sediment reduction projects, which include source identification, reduction plans, and implementation activities. Fine sediment reduction improves water quality and habitat complexity, and can increase the likelihood of spawning success.

C. Instream habitat improvement projects. Repairing instream habitat may include actions to increase channel complexity (through boulder or large woody debris placement), modify local channel gradient, and reconnect floodplain.

D. Barrier removal projects, which include actions to quantify the extent and quality of coho habitat above barriers, draft alternative structure designs, and execute barrier removal. Depending on the location of these barriers, their removal could reconnect large reaches of coho habitat.

E. Habitat conservation, which may include actions to acquire easements or purchases of lands or corridors identified as having important value to coho salmon. Conservation efforts are intended to protect habitat from potential future degradation.

Landowner outreach and education are important components of all these activities. Partnerships among many groups, including the Sotoyome and Gold Ridge Resource Conservation districts, NMFS, CDFG, SCWA, and Trout Unlimited have begun R/C/A activities in the areas identified as primary coho watersheds (See Appendix A). However, given the extent of development in the watershed, it is likely that additional efforts will be necessary to restore watershed processes (through riparian and instream restoration) to benefit coho salmon in each stream system identified here. Partnerships with local conservation organizations such as the Sonoma County Agricultural Preservation and Open Space District and the Sonoma Land Trust, and many others, will be expanded.



VERIFY SCALES
ONE INCH

PRUNUSKE CHATHAM, INC.
400 MORRIS STREET, SUITE G
SEBASTOPOL, CA 95472
(707) 824-4600

DATE: 12/10/12
SCALE: AS SHOWN
DESIGNED BY:
DRAFTED BY: JP, BKS
CHECKED BY: JP, LH

REVISIONS	DATE	BY

PREPARED FOR:
GOLD RIDGE RESOURCE CONSERVATION DISTRICT

WESTMINSTER WOODS WATER TANK PROJECT

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SHEET 1 OF 2

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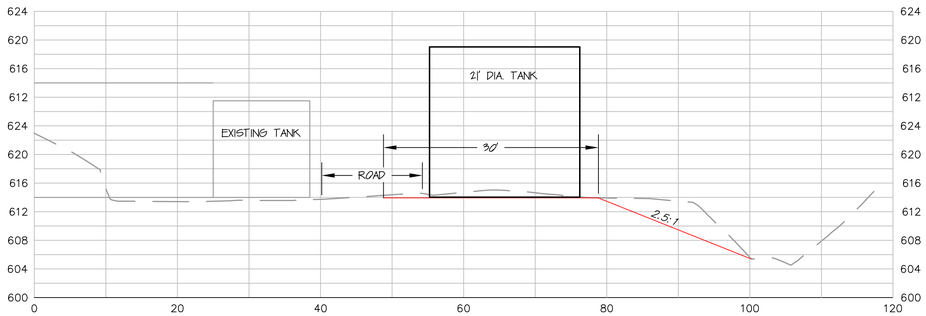

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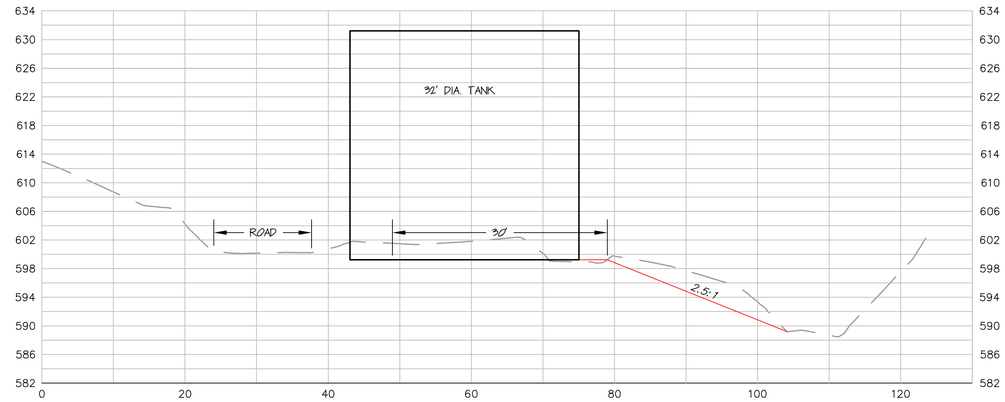

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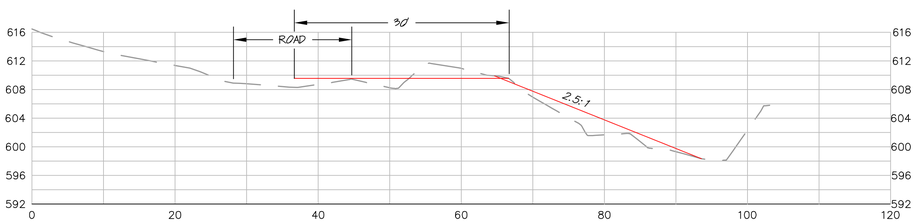

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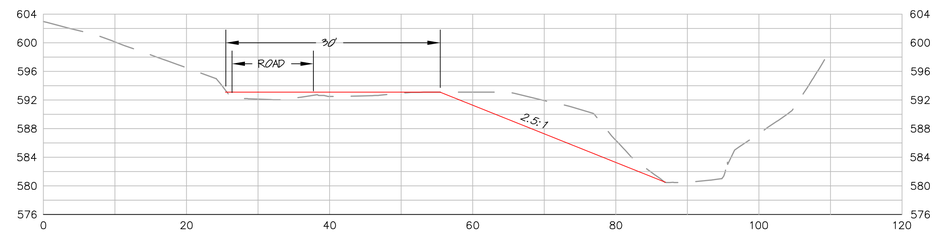

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SCALE: AS SHOWN
DESIGNED BY:
DRAFTED BY: BKS
CHECKED BY: JP, LH

REVISIONS	DATE	BY

PREPARED FOR:
GOLD RIDGE RESOURCE CONSERVATION DISTRICT

WESTMINSTER WOODS WATER TANK PROJECT

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SHEET 2 OF 2

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PRUNUSKE CHATHAM, INC.

M E M O

Date: October 12, 2012

To: John Green, Gold Ridge RCD

From: Lauren Hammack, PCI

Subject: Westminster Woods Water Saving Measures

As part of the Westminster Woods Water Storage Project Feasibility Analysis, Prunuske Chatham, Inc. (PCI) has evaluated several options to reduce the irrigation needs of Westminster Woods. The water saving measures chosen for implementation will determine the winter storage volume required to eliminate the withdrawal of irrigation water from Dutch Bill Creek during low-flow periods. This memo outlines the different water saving measures available. Rough cost estimates for each of the options have been developed for planning purposes. The table below summarizes water irrigation demands and its controlling factors, as well as approximate costs of each of the options. For comparison and planning purposes, irrigation water storage potential within the Spring Canyon area has been estimated at up to 243,000 gallons.

Option:	**6-month demand (gallons)**	**4-month demand (gallons)**	**Approximate Cost**
No change	735,000 to 900,000	490,000	$0
Reduce turf area*	480,000	340,000	$8,000-$10,000
Replace turf type*	240,000	170,000	$20,000-$45,000
Install smart irrigation features**	+15%	+15%	$3,000-$5,000
Replace irrigation system**	+0-40%	+0-40%	$18,000
Amend, aerate, and compost soil**	+10-30%	+10-30%	$8,000

*These estimated water demands are based on an efficiently operating irrigation system and aerated soil.
**Not implementing these options can increase water demand by the percentages shown.

Existing Irrigation Use

PCI has estimated the existing irrigation use at Westminster Woods for the playfield, tent camping area, and volleyball surrounds to be approximately 735,144 gallons per year. This is based on a six month watering period, delivering 1” per week to 49,075ft^2

of turf. With the standard 75% efficiency rate of traditional spray heads this number will be 25% higher pushing existing irrigation use up to over 900,000 gallons a year. This estimate is a minimum and will increase if the irrigation system has leaky valves or pipes, unevenly spaced heads with unmatched precipitation rates, and if subject to periods of overwatering. This estimate would also be higher if the soil is compacted and the turf not well managed.

Water Saving Measures

The irrigation demand for Westminster Woods depends on the water saving measures they chose to adopt. Listed below are some conservation measures, their estimated water savings, and costs where feasible to determine.

1. **Reduce Turf Area**

   The existing 49,075ft^2 of turf could be reduced to 32,000ft^2 by decreasing the size of the playfield and tent area and removing volleyball surrounds turf completely. The volleyball surrounds and softball diamond could be surfaced with woodchip mulch or a synthetic material that requires no irrigation.

   Proposed turf reductions are:

   -Tent area: 19,350ft^2 reduced to 12,000ft^2
   -Playfield area: 24,700ft^2 reduced to 20,000ft^2
   -Volleyball Surrounds: 4,121ft^2 reduced to 0ft^2

   The estimated water demand after turf reduction for all three areas would be 479,360 gallons a year for a six month watering period and 339,547 gallons a year for a four month watering period. These demand values are dependent upon installing smart irrigation technology, ensuring good soil conditions, aerating the turf regularly, and the system being leak free. The existing turf areas are currently compacted and the irrigation system is old and, likely, leaky.

   The approximate costs for turf reduction are $8,000-$10,000. This includes mapping and capping lines, turf removal and resurfacing old turf areas with mulch. Removing pipe infrastructure is optional. Planting with drought tolerant natives (if desired) could occur after mulching when it suits the camp. As an alternative to mulch, turf around the playfield area can be ripped and removed, and the soil amended and sown with native grass seed in the fall.

2. **Replace existing turf**

   Replacing the existing turf with a more drought tolerant grass will reduce irrigation demand by 50%. Delta Bluegrass Company has a blend (90-10 fescue/bluegrass blend) that uses 50% of the water traditional turf grasses use. The fescues in the mix are not native, because the nature of the native fescue is slower growing and not as resilient to activity. The 90-10 fescue/bluegrass blend needs approximately 0.5” of water per week during the dry season. This

application rate is based on Delta Bluegrass's specification to apply half the reference evapotranspiration (ETo) of traditional turf to the 90-10 blend. This particular blend is 10% bluegrass, 30% avenger tall fescue, 30% titanium tall fescue, and 30% titanium lateral fescue, and is suited for high traffic areas and play fields.

The estimated water demand after turf replacement (on reduced turf area) is 239,680 gallons a year for the May through October six month period and 169,773 gallons a year for the July through October four month period. These demand values are dependent upon installing smart irrigation technology, ensuring good soil conditions, aerating the turf regularly, and the system being leak free.

The camp will need to decide whether to grow the lawn from seed or lay down sod. In the long run, if replacing the grass on a playfield, the cost difference between laying sod versus seeding can be pennies. This has to do with required maintenance (pulling weeds, erosion, reseeding) and loss of field play time associated with seeding. Westminster will likely lose the field for an entire season if they chose to seed it; waiting for the grass to grow in – from seed to play time – would be 6 months to 1 year. If sod is laid the weeds will be suppressed and the field will be playable within a month.

The approximate cost of sod installed is 40 cents a square foot. Laying sod on the playfield will cost $11,500 and $7,000 on the tent area. These costs are in addition to grass removal and soil prep. Grass removal and soil prep is estimated to be $10,000-$15,000 for the playfield and $7,000-$10,000 for the tent area. Composting old sod onsite would be cheaper than off-haul.

Alternatively the fields can be seeded, which will be much cheaper initially and with good maintenance is a fine choice. Cost for seed and mulch installed is approx. $2,500 for playfield and $1,800 for the tent camping area.

3. **Utilize Smart Irrigation Technology**
   Utilizing smart irrigation technology is the key to water savings. The system will run more efficiently and more water will go to plant needs and not be wasted.

   a. *Irrigation audit*. Westminster should have the existing system checked to see if there are any major leaks in pipes, valves, etc. If there is uneven pressure throughout the system the reason could be a leak. The cost for an irrigation audit is $180 per valve. An audit of the existing system at Westminster is estimated to be $1000-$1,500.

   b. *Change out sprinkler heads*. Traditional spray heads can be converted to MP Rotators by Hunter. Traditional spray heads are 75% efficient

while the MP Rotator is 85% efficient. The MP rotator delivers streams of water (vs. spray) at a slower, steadier application rate allowing for greater soil infiltration, less evaporation and runoff. The initial application rate would still be an average of 0.5" weekly to the drought tolerant turf, but there will be less waste and more infiltration, potentially reducing the application rates after establishment. Even without replacing the laterals and valves, the heads alone could be replaced for significant water savings. The cost of an MP Rotator head is approx. $5 each plus the labor to install.

c. *Install a smart controller*. A smart controller is a weather sensor that adjusts controller run times based on daily weather conditions and increases system efficiency. These are great to have if there is not an attentive maintenance staff adjusting the irrigation controller according to weather. We have all experienced unnecessary irrigation, such as sprinklers on in a rain storm. Controllers (up to a 15 station) run $200-$500 depending on features, plus the cost of installation.

4. Replace entire irrigation system

If the existing system is old and has leaks and spotty coverage it should be replaced entirely. Leaks can account for up to 40% of water demands. If the existing turf is planned to be removed and the field ripped, it makes sense to replace the system at this time.

The cost for replacing the entire irrigation system in the playing field is $12,000 (includes controller costs) and the cost for replacing the entire system in the tent camping area is approximately $6,000. The cost for design would be additional.

5. Amend, Aerate & Compost Soil

Soil at the camp should be tested to see if it is heavy in clay and if sand needs to be added. Testing percent organic matter (we want good infiltration) is also suggested. Ideal soil composition for turf is 30% sand, 40% soil, and 30% organic matter (by volume). Compost (organic matter) should be approximately 5% composition by weight.

Compaction is a sports field's worst enemy; it will inhibit and slow the infiltration of water. Smaller soil pore spaces from compaction also increases soil temperatures and decreases nutrient movement. Compaction results in increased runoff, and thus more irrigation is required to saturate the soil and support grass growth. The camp should be core aerating the field 1-2x per year. At this time they can also top-dress it with compost or apply a compost tea. Application of compost during routine aeration would be 1/2" of compost/sand mix. If the turf is replaced entirely, soil should be tilled to 6" deep with 1-2"

compost mixed in. Compost is an alternative to conventional fertilizers, which can add unwanted nutrient levels into the creek. If conventional fertilizers or high nutrient composts are added to the turf, a riparian filtration feature would be something to think about.

The compost will benefit the soil by improving aeration, providing nutrients, and increasing its water and nutrient holding capacity. The compost needs to be finer in texture for uniformity but with a woody enough texture for hydraulic conductivity. Compost and aeration both greatly benefit the drought tolerance of turf. Gypsum can also be added to fight compaction.

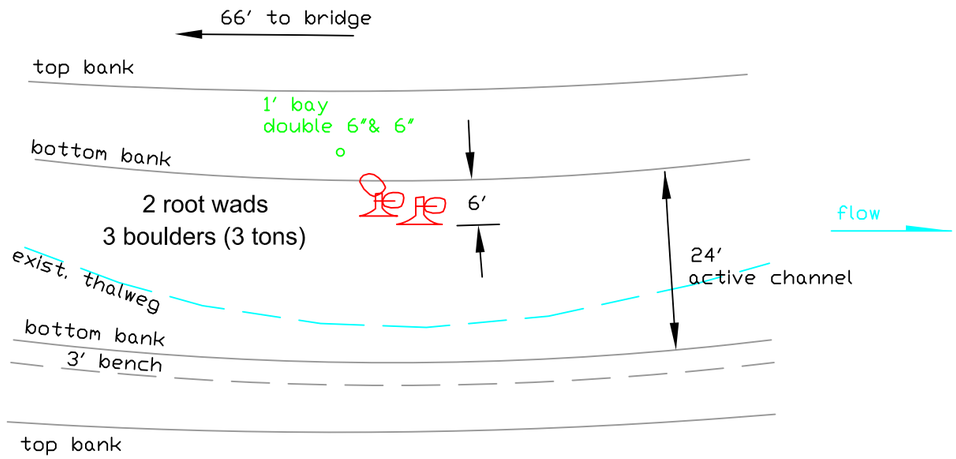
It is difficult to quantify the exact water savings based on increased infiltration rates of soil. But if the soil is healthy the need to increase irrigation application rates will be greatly reduced.

Compost cost can range between $15-20 a yard. The cost to amend and aerate the playfield would be $5,000 and the cost to ament the tent area would be $3,000.

6. **Ongoing Management**
   Management is another key to long term success for water savings. If the field becomes too compacted, the irrigation system has unidentified leaks, sprinkler heads are broken, and weeds take over, the amount of water required to keep that turf hydrated could easily double from estimates given above. A one or two page management plan could be written up, as a guidance document for the camp to follow. The cost for a management plan would be approximately $1,000-$1500.

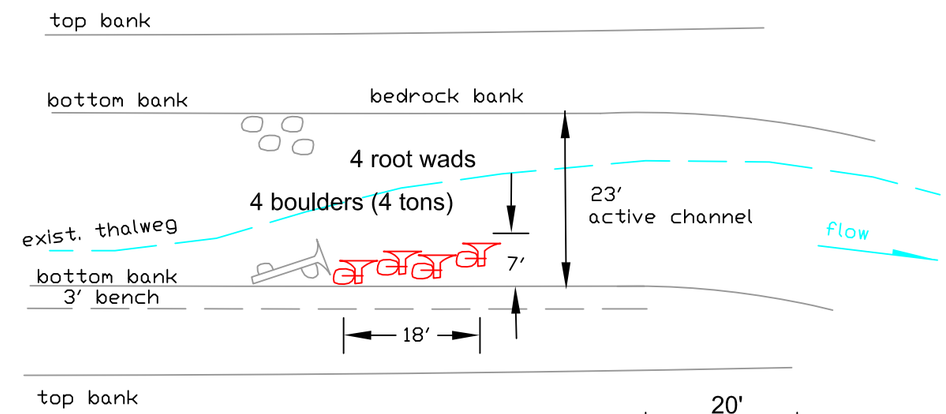
Estimated Water Storage Volumes within Spring Canyon

The maximum storage potential up Spring Canyon is estimated to be 242,750 gallons, but may be less depending upon geotechnical and permit site restrictions. The upper site could hold a 21’diameter x 20’ tall tank with a storage capacity of 54,500 gallons. The lower site could hold a 32’ diameter x 30’tall tank with a storage capacity of 188,250 gallons. 30,480 gallons of pool water will also be available for use if supplemental water is needed.



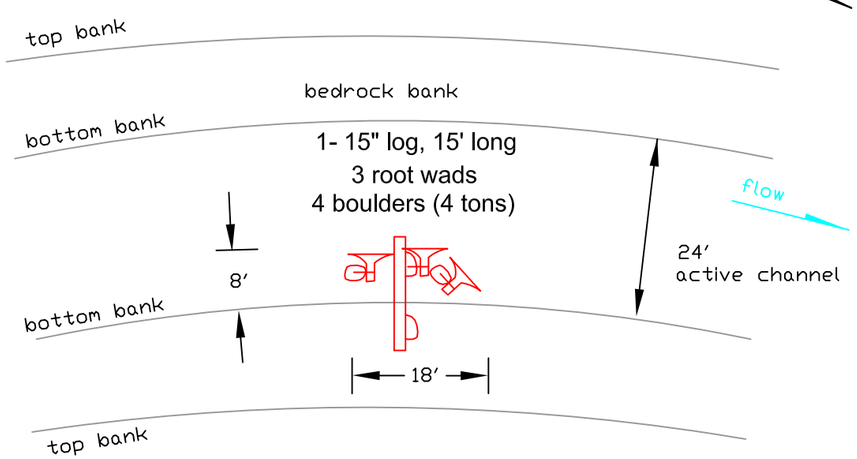
SITE 1
high flow refuge
& pool formation

20′
Graphic Scale



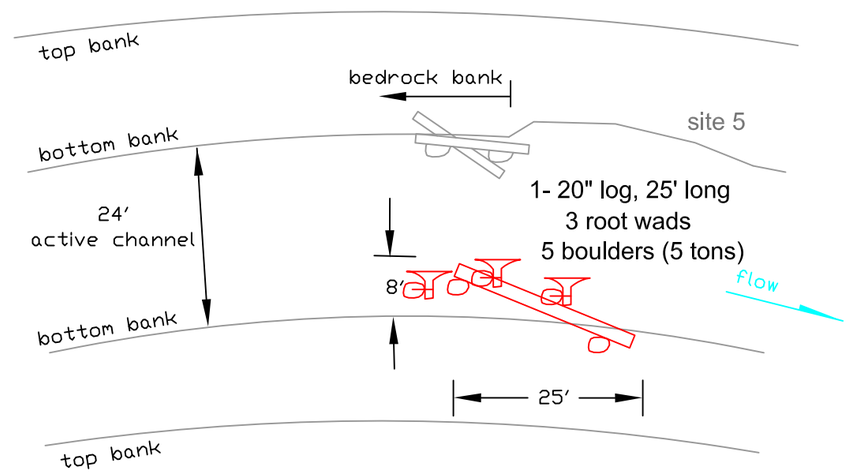
SITE 2
enhance exist. structure
pool shelter
high flow refuge

20′
Graphic Scale



SITE 3
high flow refuge
pool formation
pool shelter

20′
Graphic Scale

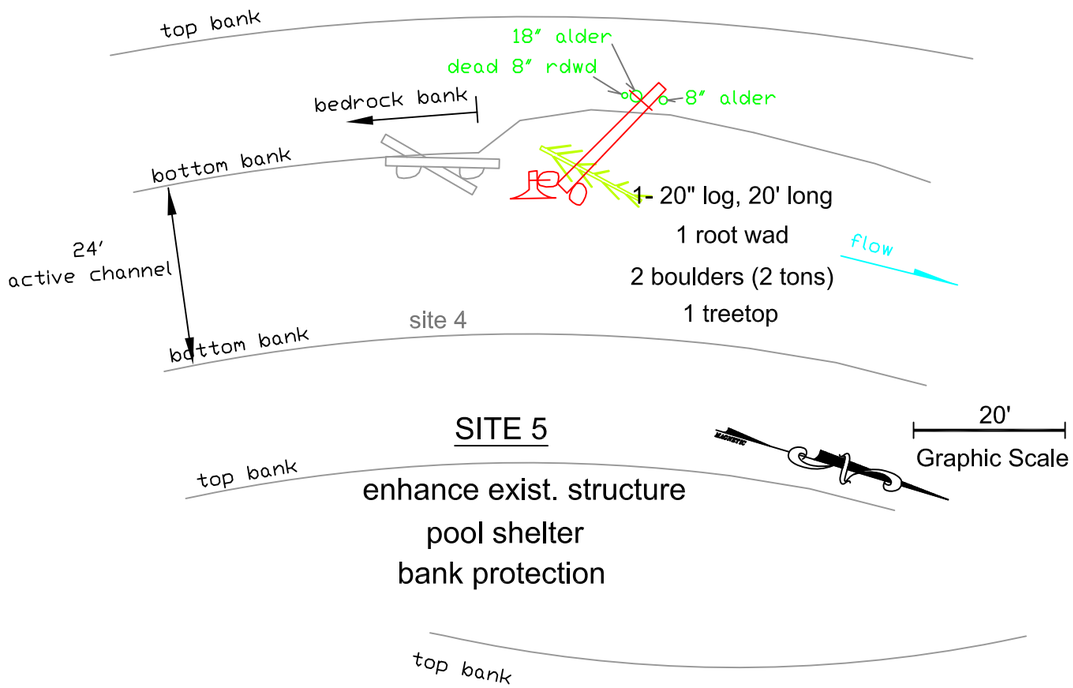


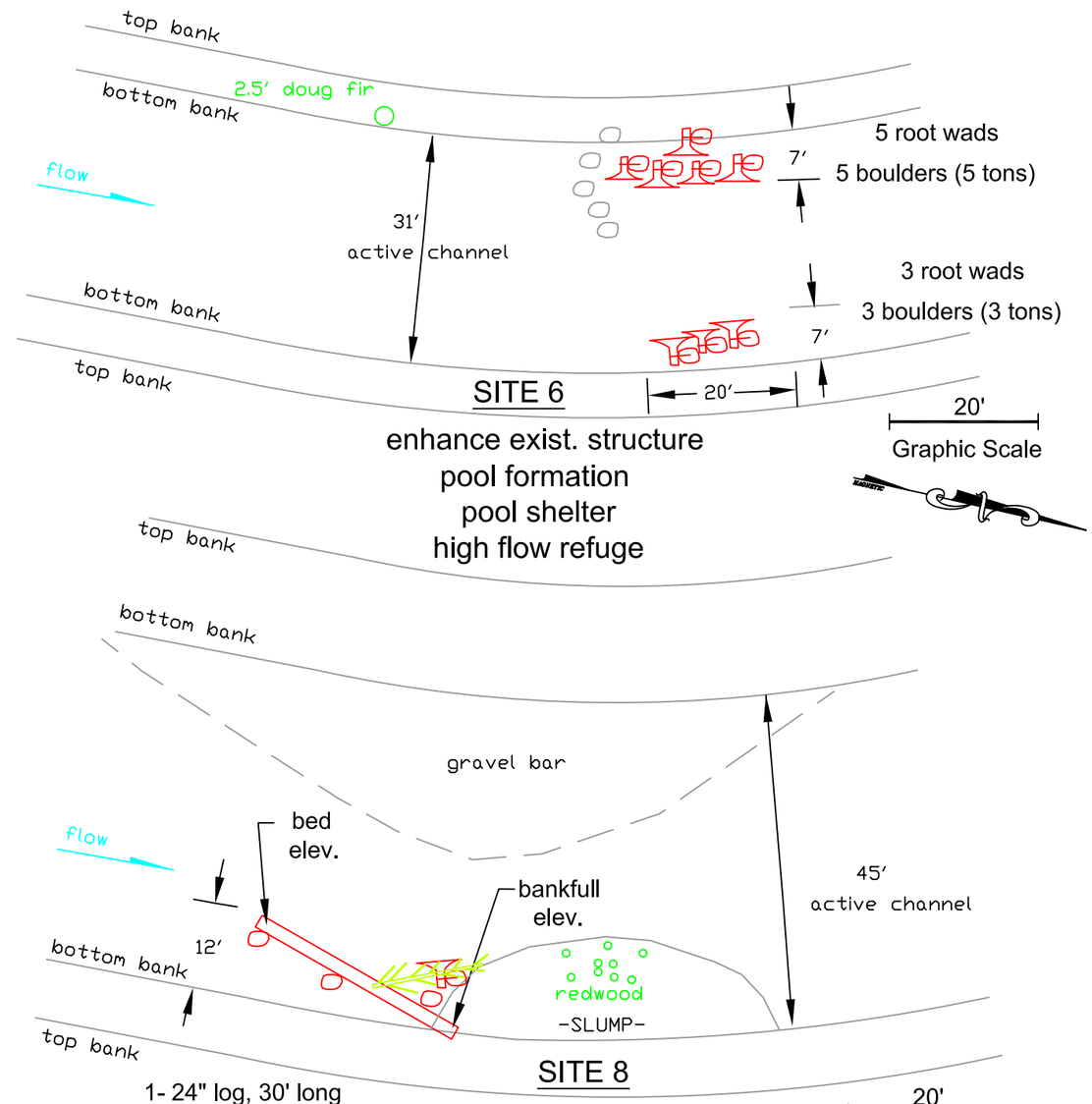
SITE 4
enhance exist. structure
pool formation
pool shelter

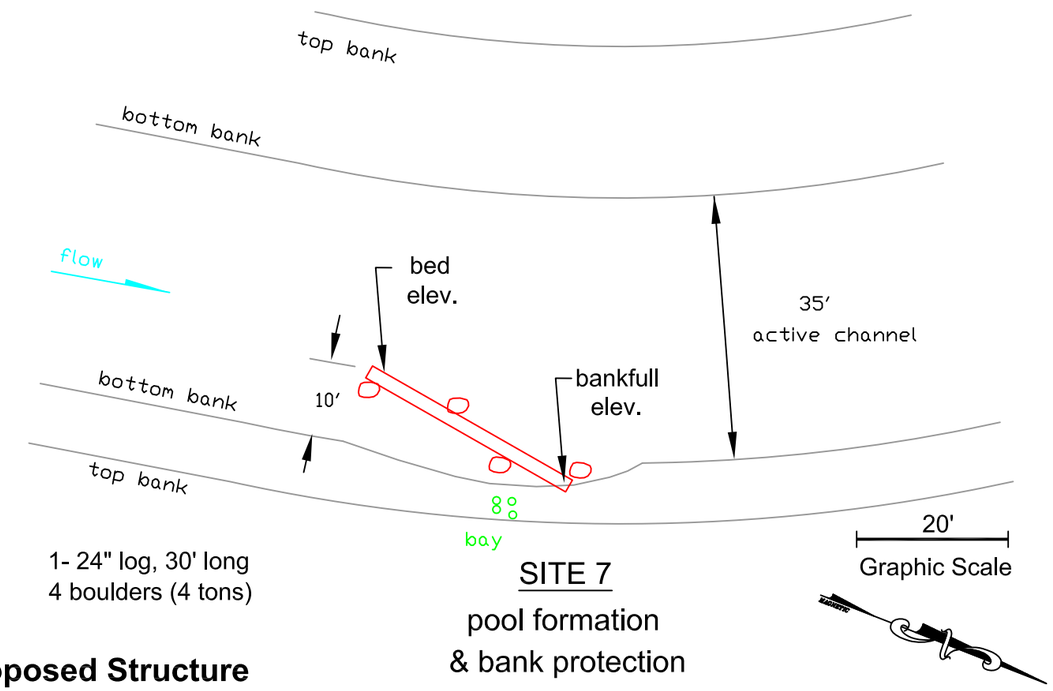
20′
Graphic Scale

Red = Proposed Structure

STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **1** of 7

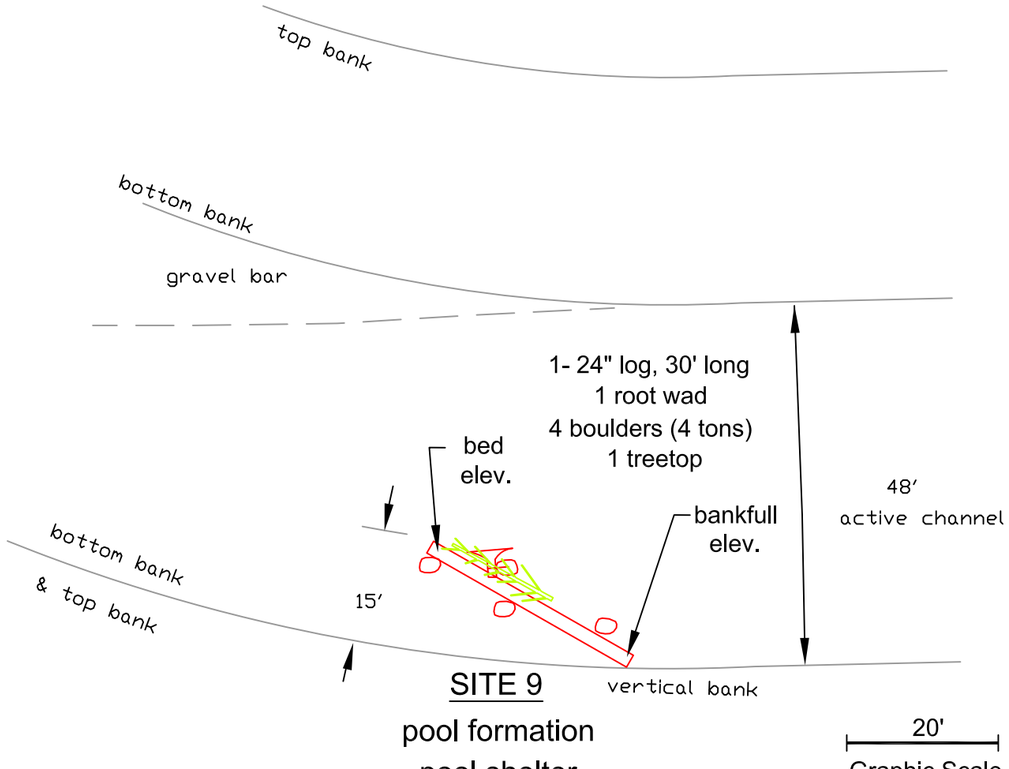






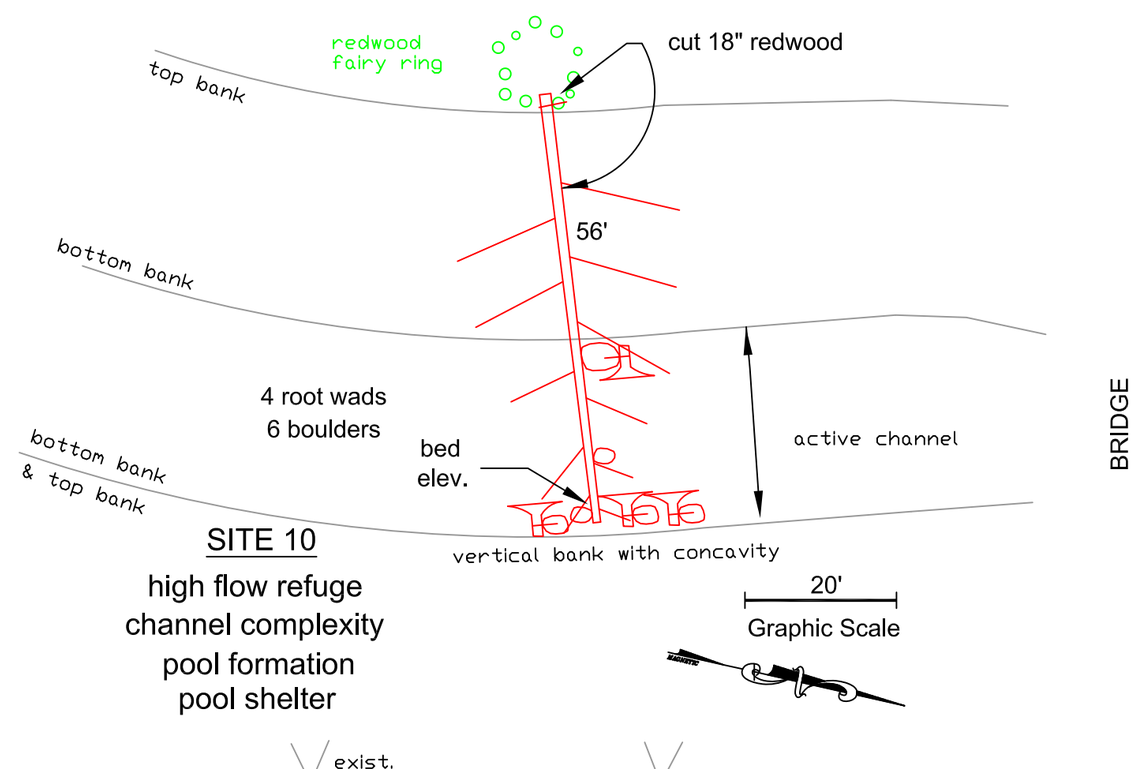
Red = Proposed Structure

STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **2** of 7



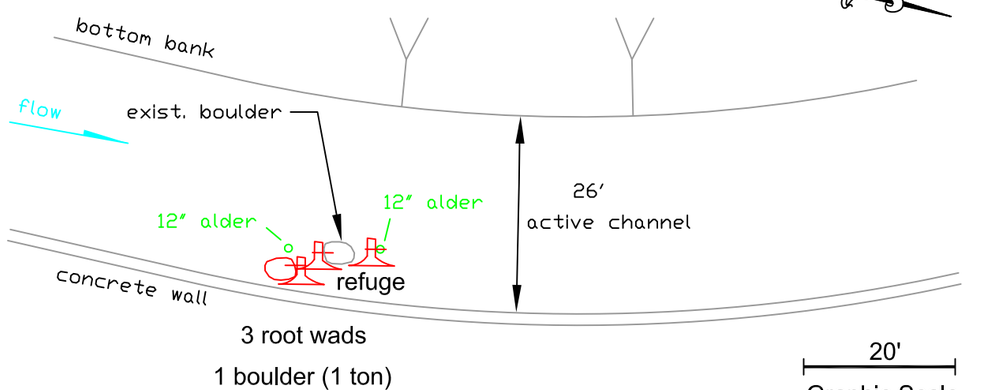
SITE 9

pool formation
pool shelter
bank protection



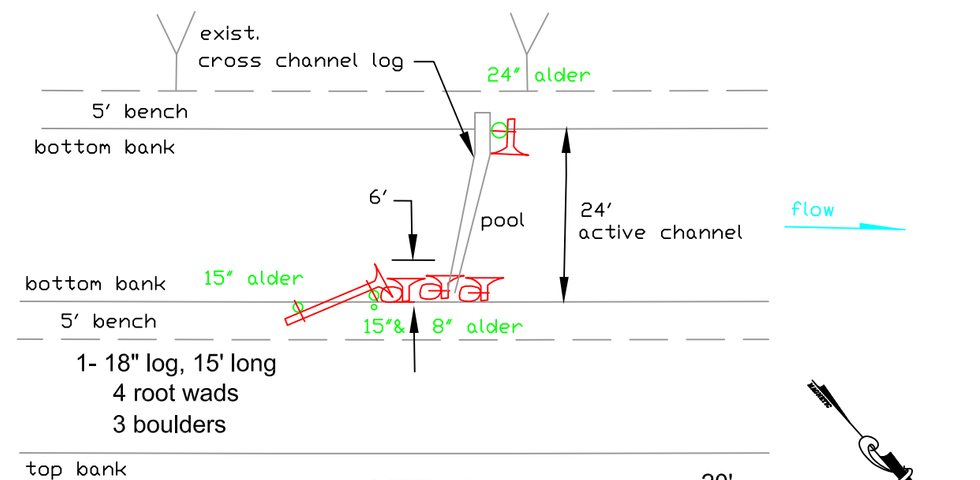
SITE 10

high flow refuge
channel complexity
pool formation
pool shelter



SITE 11

high flow refuge



SITE 12

enhance exist. pool
pool shelter

Red = Proposed Structure

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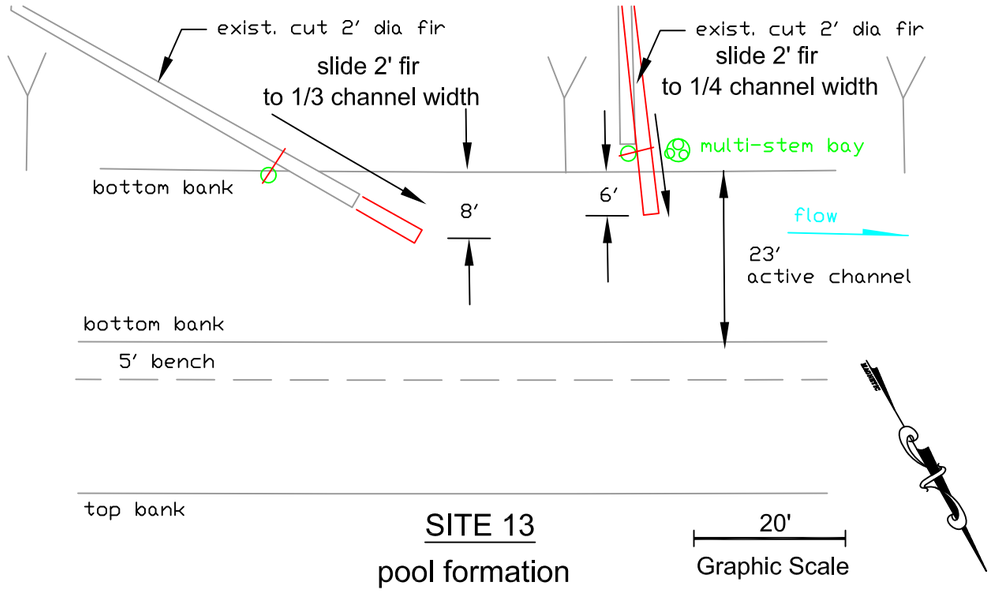
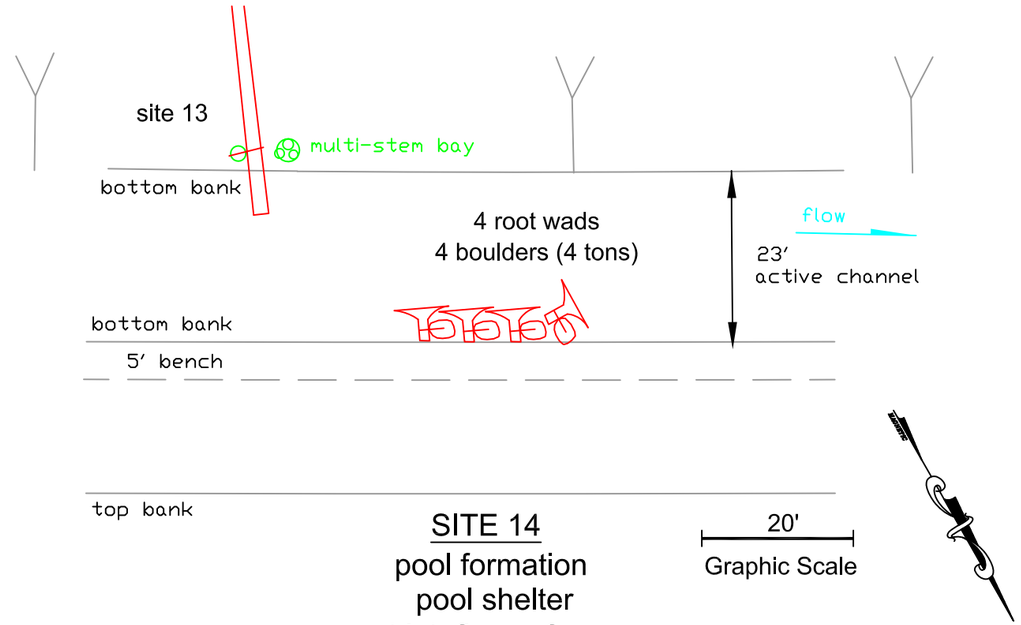


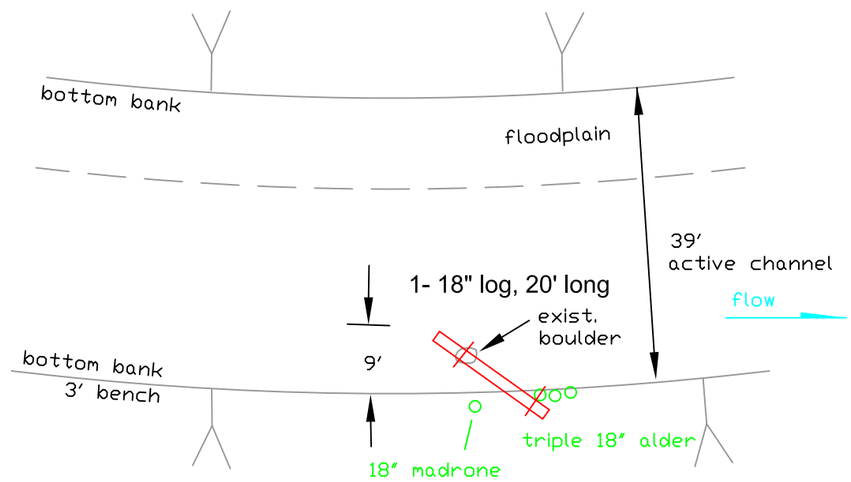
SITE 13

pool formation
high flow refuge



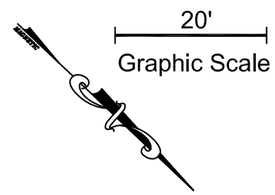
SITE 14

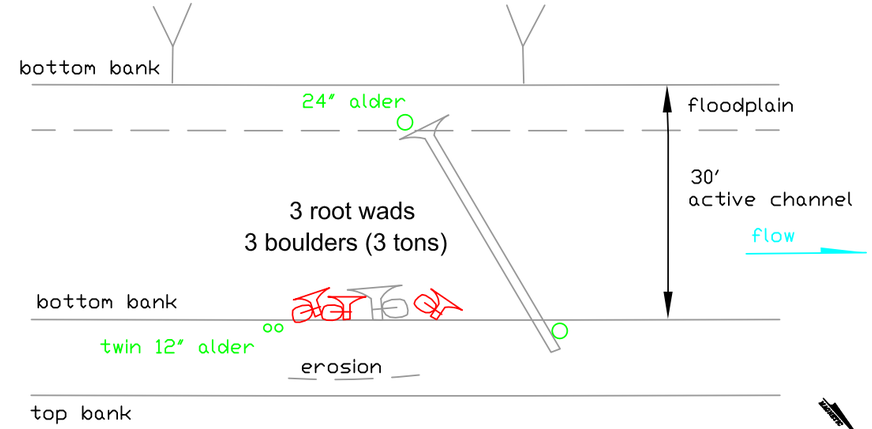
pool formation
pool shelter
high flow refuge



SITE 15

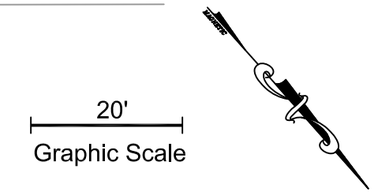
pool formation





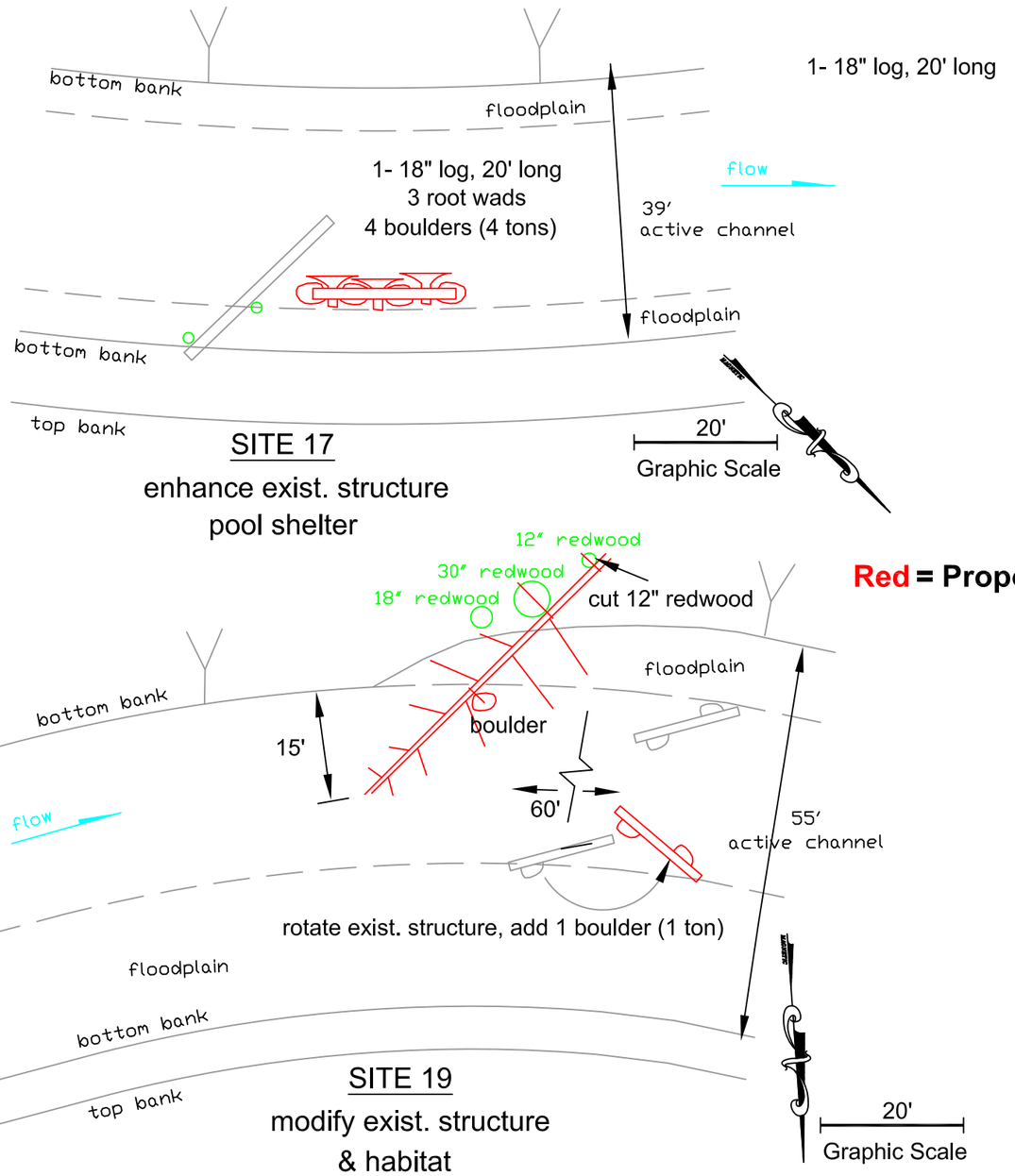
SITE 16

enhance exist. structure
pool formation
pool shelter

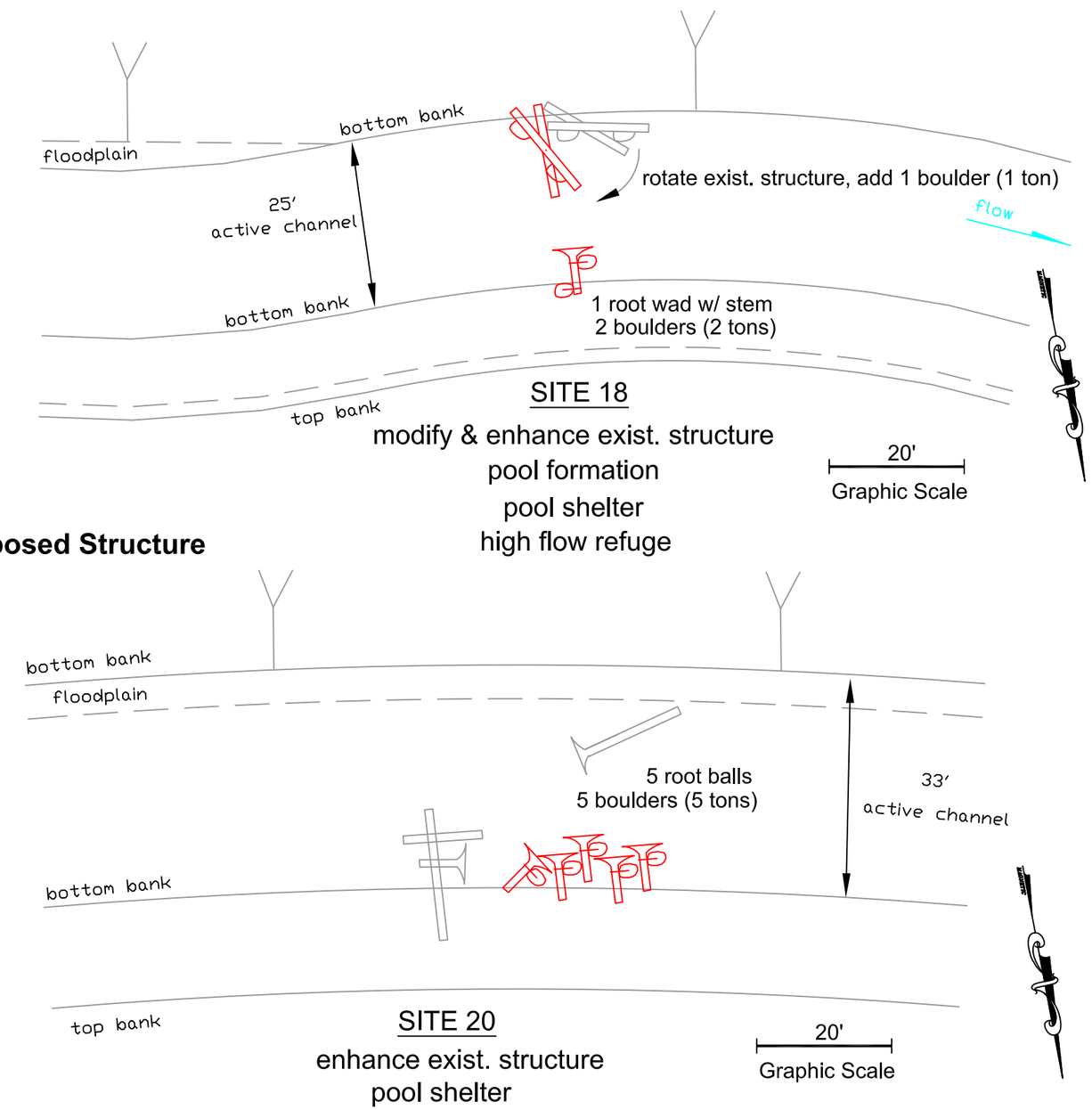


Red = Proposed Structure

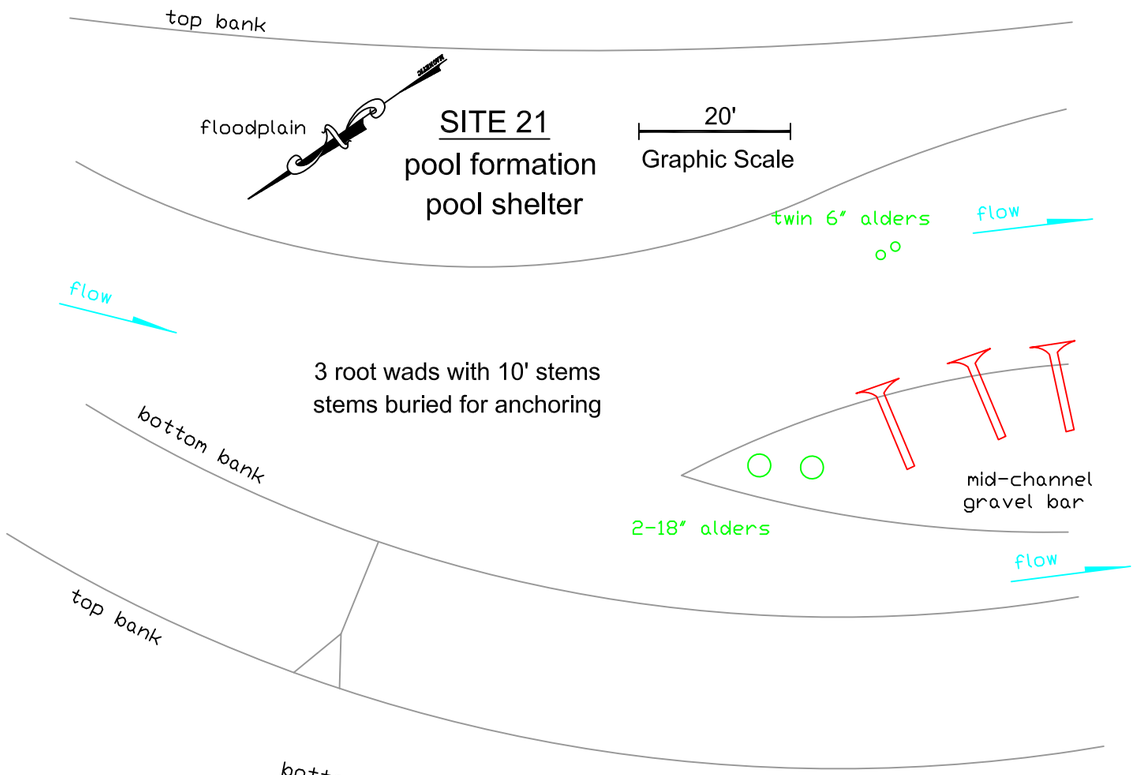
STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **4** of 7

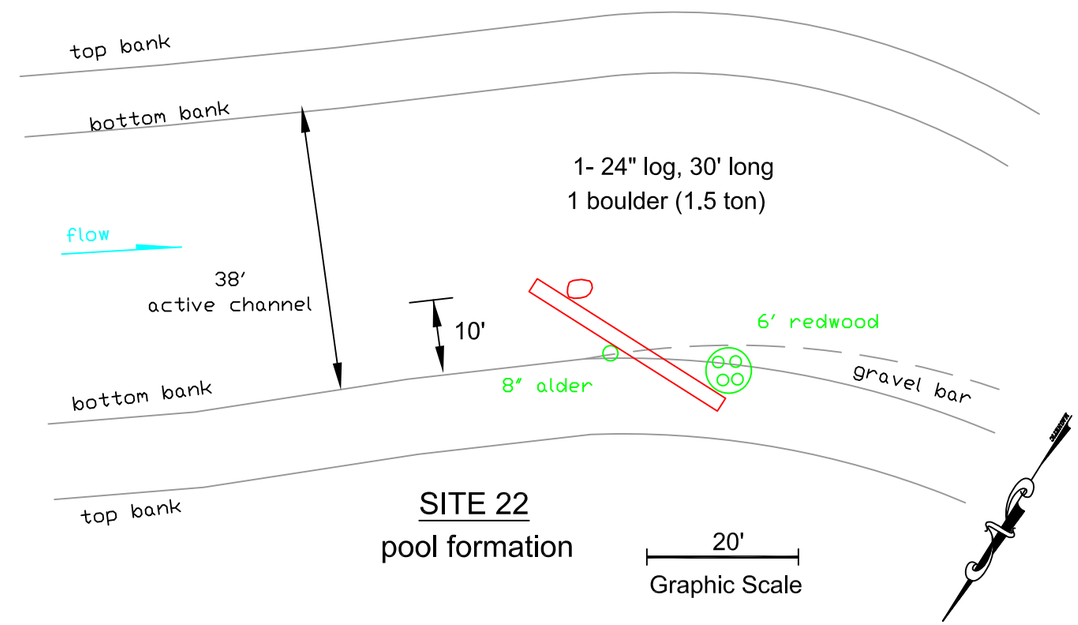


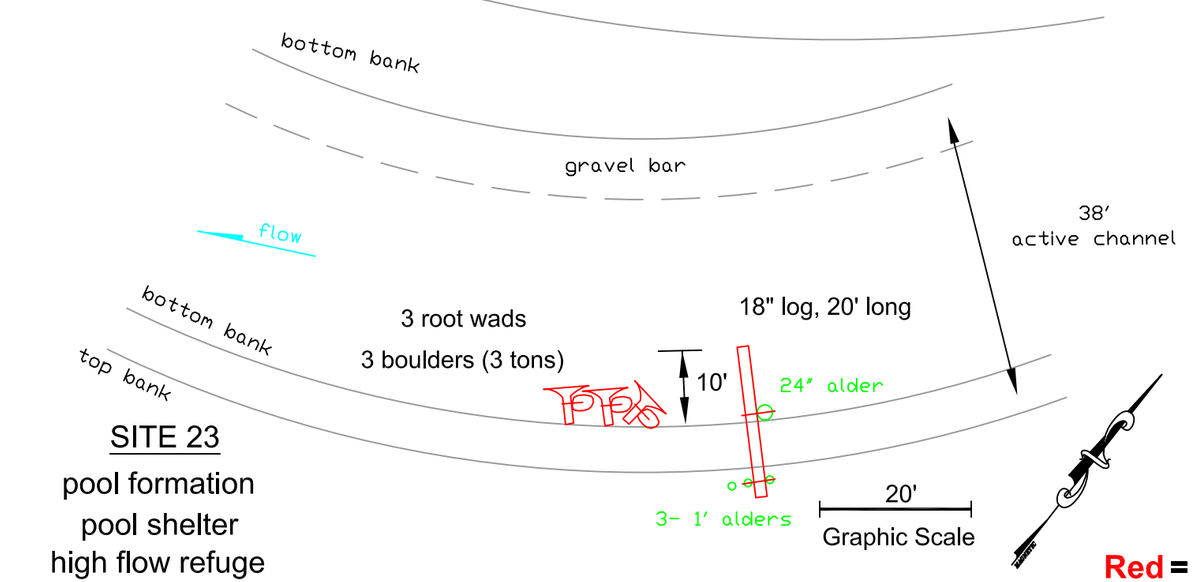
Red = Proposed Structure

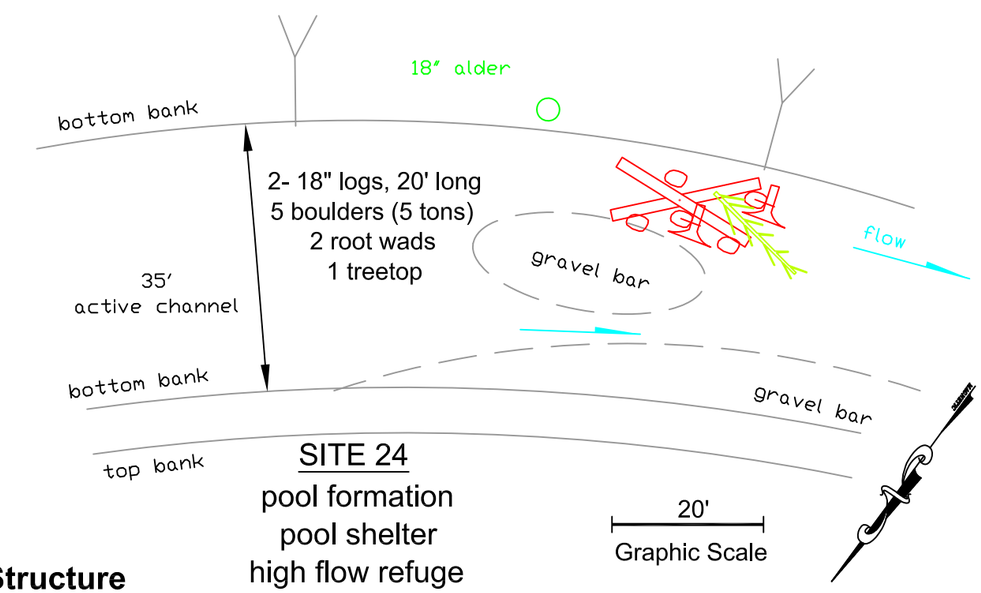


STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	**Sheet** **5** **of 7**



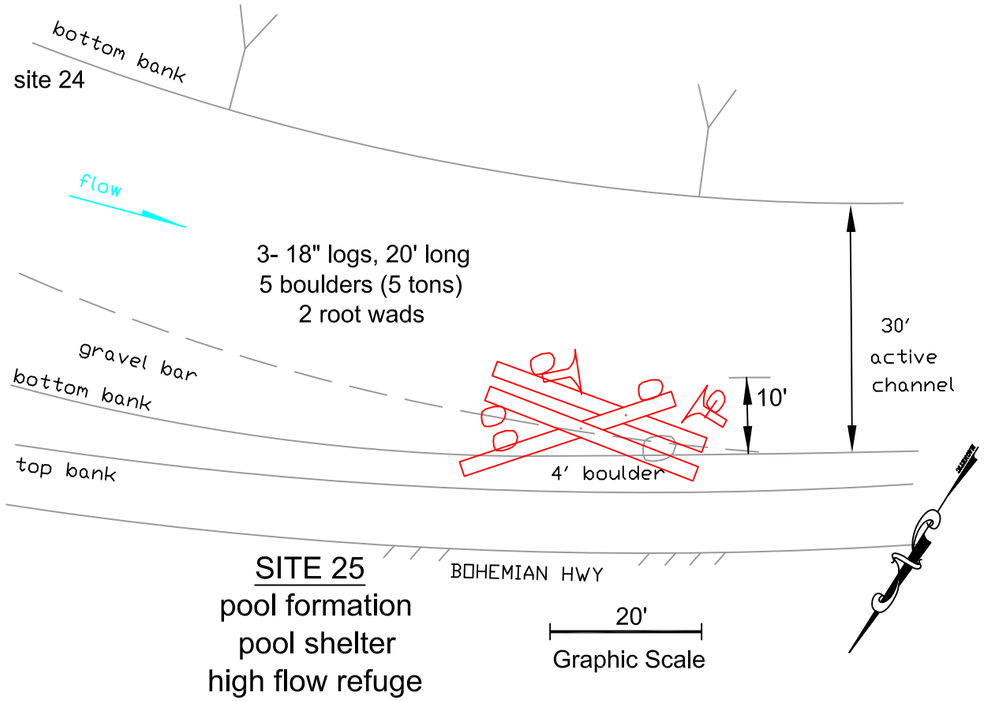




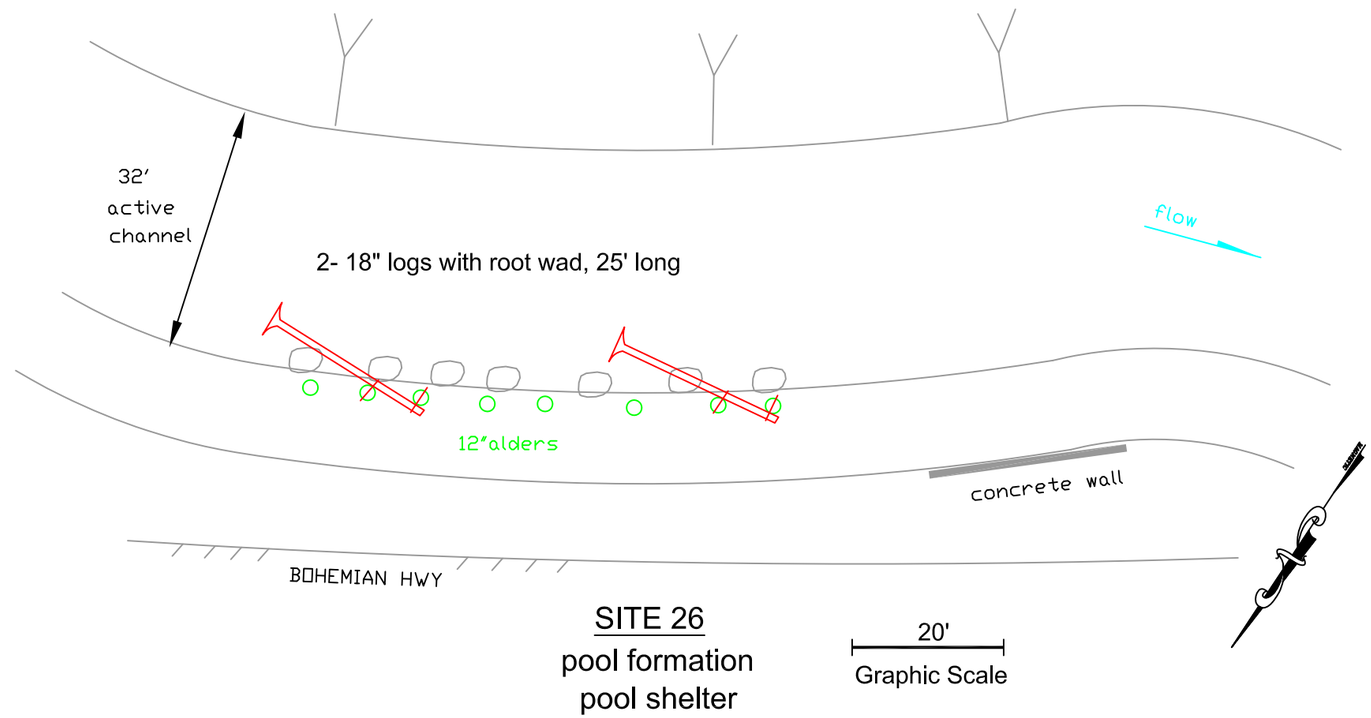


Red = Proposed Structure

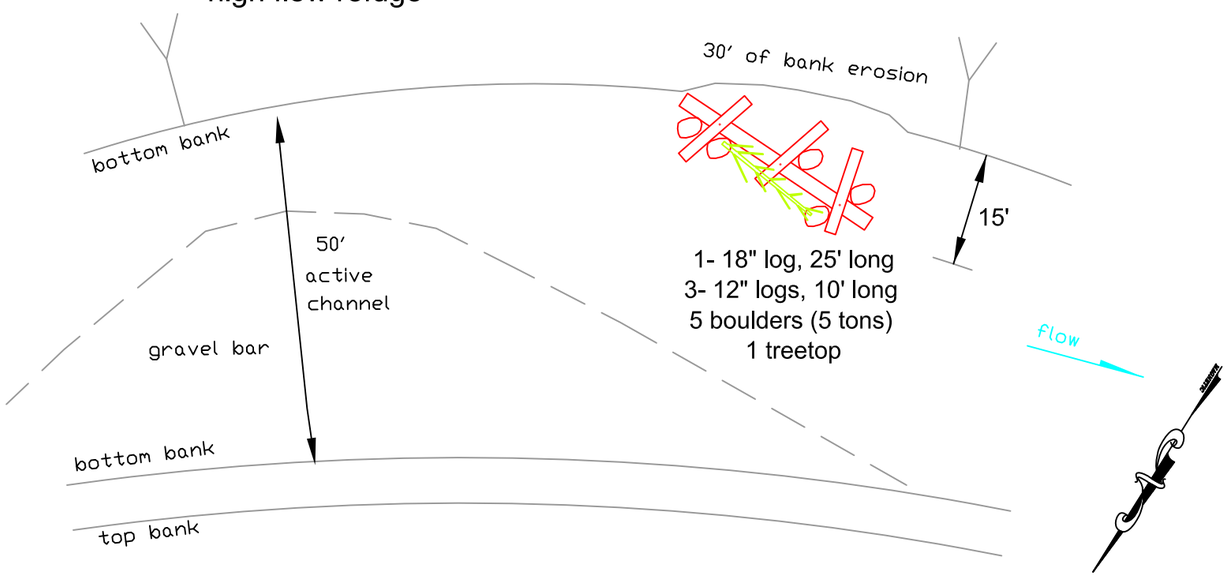
STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	**Sheet** **6** **of 7**



SITE 25
pool formation
pool shelter
high flow refuge



SITE 26
pool formation
pool shelter



SITE 27
pool formation
pool shelter
high flow refuge
bank protection

20'
Graphic Scale

Red = Proposed Structure

STREAMLINE ENGINEERING Eric Austensen, P.E. 11203 Vellutini Rd. Forestville, CA 95436 (707) 887-0101	DATE: 3-9-11 SCALE: 1"=20'	Prepared for: Gold Ridge RCD PO Box 1064 Occidental, CA 95465	**Woody Debris Placement** **Dutch Bill Creek** **Camp Meeker**	Sheet **7** of 7